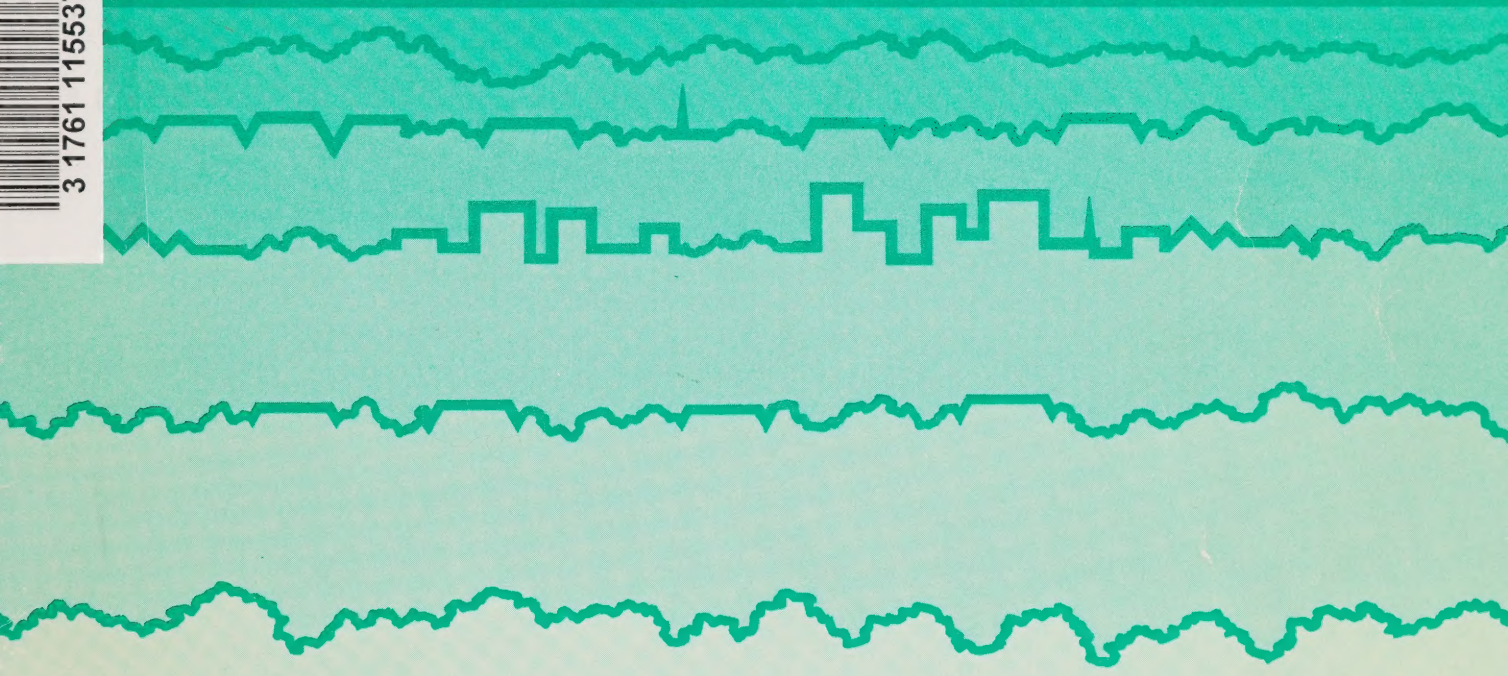
CEARC Canadian Environmental Assessment Research Council

CCREE Conseil canadien de la recherche sur l'évaluation environnementale



LEARNING FROM EXPERIENCE: A STATE-OF-THE-ART REVIEW AND EVALUATION OF ENVIRONMENTAL IMPACT ASSESSMENT AUDITS

David A. Munro, Thomas J. Bryant, and A. Matte-Baker

LEARNING FROM EXPERIENCE: A STATE-OF-THE-ART REVIEW AND EVALUATION OF ENVIRONMENTAL IMPACT ASSESSMENT AUDITS

David A. Munro, Thomas J. Bryant, and A. Matte-Baker
Naivasha Consultants
Sidney, British Columbia

A Background Paper Prepared for
the Canadian Environmental Assessment
Research Council

Cat. No. En 107-3/6-1986E

ISBN 0-662-14781-2

FOREWORD

The Canadian Environmental Assessment Research Council (CEARC) was established on January 30, 1984 by the federal Minister of the Environment to advise government, industry and universities on ways to improve the scientific, technical and procedural basis for environmental impact assessment (EIA) in Canada.

CEARC is currently in the process of establishing research programmes related to improving the practice of environmental assessment. The Council has identified "Post-development Evaluation" as one of the priority research areas and plans to publish a research prospectus dealing with this subject by the end of 1986.

The purpose of commissioning this paper, and indeed of all the other CEARC-sponsored background documents, is to provide relevant information and to stimulate discussion on the topics of interest to the EIA community. The opinions expressed, however, are strictly the authors' own and do not necessarily reflect the views of the members of the Council or its Secretariat.

For more information pertaining to the Council's general activities and its publications, please contact:

Dr. M. Husain Sadar
Manager, CEARC
13th Floor, Fontaine Building
200 Sacré-Coeur Blvd.
Hull, Quebec
K1A 0H3

Tel: (819) 997-1000

Learning from experience is a faculty almost never practiced.

Barbara W. Tuchman
The March of Folly

CONTENTS

PREFACE

This review of the results of environmental impact assessment audits was commissioned on the recommendation of the Canadian Environmental Assessment Research Council (CEARC) by the Federal Environmental Assessment Review Office (FEARO). FEARO is associated with, but independent of, Environment Canada and reports to the Minister of the Environment.

The study is based upon 10 follow-ups of EIAs, initiated by the Environmental Protection Service (EPS) of Environment Canada (see Appendix I: EPS Follow-up Studies). It integrates the results of those studies with published information from other studies undertaken in Canada and elsewhere.

The authors are grateful to FEARO and EPS for the opportunity to investigate an interesting and important subject. They are also grateful to the authors of the follow-up studies and other persons who took part in the workshop on EIA audits held in Toronto in July 1985 (see Appendix III). Discussions among the workshop participants contributed to the formulation of the conclusions reported in this paper but the authors are solely responsible for their final form.

EXECUTIVE SUMMARY

Environmental impact assessments are needed to identify, predict and assess the consequences of proposed development activities. After 15 years' experience, the extent to which EIAs meet those needs has been largely untested. This review of relevant literature and particularly of 10 follow-up studies ("audits") of EIAs commissioned by Environment Canada, can serve as a first step in evaluating the present status of the EIA process in Canada.

Hitherto there have been few deliberately planned audits of EIAs, but studies of environmentally important projects that have some of the attributes of audits, and of the 10 case studies, provide sufficient evidence that worthwhile audits can be made and support the conclusions that follow.

The process of EIA including mitigation has lessened the adverse impacts of development and reduced the controversy aroused by environmental issues.

The science upon which EIA is based and the techniques upon which it depends can be improved if

- the requirements for pre-project, operational and effects monitoring are met by systems designed in accordance with the concept of valued ecosystems;
- monitoring is begun at the earliest stage of project planning and extended over a period that will enable the separation of phenomena resulting from natural variability from project-induced effects;
- monitoring is aimed at establishing statistically significant conclusions;
- understanding of the cumulative effects of environmental perturbations is improved;
- the dynamics of ecosystem functioning are better understood;
- complete records are maintained of project implementation and mitigation and of the observed effects.

The process of EIA and its management can be improve if

- environmental impact assessment is more closely integrated with development planning;
- responsibilities among involved parties are clearly defined and maintained;
- overlapping responsibilities are reduced or eliminated;
- administrative procedures are simplified;
- the development of skills in interpersonal and group relationships is emphasized;
- timely, well presented information on all aspects of EIA and EIA audits is broadly disseminated;
- the costs of assessment (including monitoring) and mitigation are better defined and accounted for.

Audits and evaluations can be useful in improving EIAs and environmental management generally. More projects that have already been completed should be evaluated and audits of future projects should be undertaken as a matter of routine.

CHAPTER 1: THE SIGNIFICANCE OF EIA AUDITS

THE CONTEXT

As the extent and consequences of environmental degradation and careless use of natural resources have become better known, widespread concern has arisen about the nature of development. Taking social and environmental as well as economic factors into account has raised questions about the relationship between the benefits and costs of development programs and projects. If the moral obligation to see that development yields benefits to future generations is also taken into account, the questions become more complex.

A response to these concerns and questions has been the concept and practice of environmental management, used in the sense noted by Eagles (1984) to refer to the entire process of planning, managing and conserving the environment and natural resources. Environmental management is a set of activities and procedures, properly seen as integral elements of the development process, aimed at ensuring that development activities affecting the environment:

- provide net benefits to society,
- are sustainable,
- allow for the continuation of valuable non-consumptive uses of ecosystems.

Environmental management may be supported or enabled by legislation, facilitated by governmental and private machineries, and undertaken by means of governmental and private institutional arrangements and bureaucratic processes. It includes a broad range of scientific, administrative and consultative activities.

Ideally, environmental management should embrace the process of development from decision to implementation and beyond. It should contribute to the definition of social goals and objectives and to the design and evaluation of development projects affecting the environment.

Environmental management may make use of a number of techniques and procedures including integrated regional planning, the application of environmental guidelines to development, cost-benefit analysis, and environmental impact assessment (EIA). Environmental management also includes measures to mitigate the effects of development and the auditing of development projects.

EIA is clearly the currently preferred tool for environmental management at the project development stage. It has been growing not only in scientific sophistication, but also in cost and administrative burden. Many formal studies have been undertaken; numerous and voluminous reports have been written. Lengthy hearings have been held and a multitude of orders issued. But has it worked as it should? Has it helped us to move toward the goals of environmental management?

There is, in fact, growing concern about the effectiveness and efficiency of EIAs at the technical and administrative levels and about the role of impact assessment in the broader process of planning and undertaking development (ECE 1982). It is important, therefore, to examine the accuracy and utility of environmental impact forecasts and to evaluate the scientific, technical and administrative aspects of the EIA process in the context of overall development policy.

Audits of environmental impact assessments could provide the factual basis for such examination and evaluation. The U.S. Federal Council for Science and Technology (1968) was one of the first major government agencies to identify the need for follow-up research on projects. O'Riordan (1971) defined the value of "hindsight" evaluations of environmental impacts. A number of the participants in the 1977 EIA Conference at the University of Toronto Institute for Environmental Studies regretted that there had been so little follow-up and monitoring (Plewes and Whitney 1977). Munn (1975 and 1979) identified such needs in his reviews of the state of the art of EIA. Beanlands and Duinker (1983) in their comprehensive review of EIA expressed the importance of empirical tests of prediction. But follow-up of EIAs has not been common. Until now, continuous monitoring of development projects has been an infrequent practice. Audits have been commissioned for a very small proportion of the EIAs that have been made, and the number of less formal, hindsight evaluations, whether specific to a particular project or general, is also quite limited.

The broad purpose of this paper is to contribute to environmental management by examining and evaluating some aspects of impact assessment. The focus is on environmental impact assessment, in the comprehensive sense, and on mitigation. The point of departure is auditing.

The conceptual framework of this paper is that

- environmental management is a crucial requirement of any society;
- EIAs are an essential component of environmental management but they are not meeting expectations; they are often too limited in terms of time, space and policy context and have not been sufficiently tested;
- EIAs can be improved by giving better attention to scoping, baseline studies, and effects monitoring and by undertaking post-development audits as a basis for improving the

planning and management of developments, and evaluations to assess the contribution of developments to broad social goals.

PURPOSE, SCOPE AND METHODS

This paper provides a preliminary state-of-the-art review of EIA audits, drawing particularly on 10 studies commissioned by the Environmental Protection Service (EPS) of Environment Canada (see Appendix I). It also examines some of the issues that they raise. The studies are of a multi-use transportation corridor in British Columbia, highway projects in Alberta and in Alaska-British Columbia-Yukon, hydro-electric developments in Newfoundland and Nova Scotia, two mines in British Columbia, pipelines in the North, Ontario and Quebec, and oil and gas developments in the Arctic and on the Atlantic coast.

Chapter 1 of the paper outlines the context in which audits of EIAs are considered, provides brief statements of the nature of EIAs and of audits, and defines some relevant terms. Chapter 2 reviews the history of environmental audits and notes some of the less formal evaluations and interpretations that preceded them. Chapter 3 focuses on the scientific and technical issues raised by audit; Chapter 4 on their administrative and procedural implications. In Chapter 5 the main policy issues that emerged from the study are highlighted. The first two chapters are concerned with the issues in general terms, while the last three chapters refer primarily to Canadian experience and its implications.

The study was conducted by assembling, reviewing and analysing information obtained by

- searching computerized data bases for relevant titles (see Bibliography),
- manual review of current journals and other publications (see Bibliography),
- review of 10 follow-up studies of EIAs commissioned by EPS (see Bibliography and Appendix I),
- interviews and correspondence with experts in Canada, Australia, the United States and the United Kingdom (see Appendix II; cited in the text as "surname (1985-i)").

A workshop on Audits of Environmental Impact Assessment was convened to present and discuss the results of the follow-up studies and to consider scientific, procedural and policy aspects of EIA and EIA follow-up (see Appendix III, a list of participants).

TERMINOLOGY

There are many definitions of *environmental impact assessment*, perhaps the most succinct being that it is a process which attempts to identify, predict and assess the likely consequences of proposed development activities (ECE 1982).

EIA is defined by Munn (1975) as an "activity designed to identify and predict the impact on the biogeophysical environment and on man's health and well-being of legislative proposals, policies, programs, projects and operational procedures and to interpret and communicate information about those impacts."

The definition of Beanlands and Duinker (1983) adds to the preceding definitions: "to investigate and propose means of ameliorating those effects." Many terms have been used to refer to the re-examination of a project and its environment some time after an EIA has been made. The lack of a commonly accepted terminology probably results from the pursuit of a number of different but related purposes, and from the limited circulation of many of the reports and publications concerned. Whatever the causes, considerable ambiguity and confusion are the result.

Post-project analysis has been used as a very broad umbrella term (ECE 1982). EPS used the rather imprecise term *follow-up* to refer to the commissioned studies that are a major source for this paper.

The processes to which such terms as "monitoring", "audits" and "evaluation" refer are all concerned with examining natural phenomena, usually modified by human intervention, and all have overtones of surveillance and judgment. They are closely related terms and it is useful to consider their meaning and usage in some detail. It is not our purpose to propose a standard terminology but we wish to define the terms that will be used in this paper and to note some that appear to have been used more or less synonymously elsewhere.

Monitoring is repetitive measurement (Beanlands and Duinker 1983) or, less satisfactorily, repetitive qualitative observations. The term *baseline monitoring* or *pre-project monitoring* can be applied to the measurement of environmental variables during a representative period of the pre-project phase, before disturbances occur, to determine the normal range of variation of the system. The term *effects monitoring* is used to describe periodic measurement of environmental variables to determine changes attribuable to the construction and operation of projects; it can be further subdivided into *operational monitoring* or *post-project monitoring*. The usefulness of effects monitoring depends to a great extent on the existence of data against which to measure change, usually the product of baseline studies. *Compliance* or *regulatory monitoring* and *surveillance* which take place during the operational or post-project stages are directed towards ensuring that regulations are observed or standards met. These types of monitoring do not necessarily involve measurement and need not be repetitive.

Monitoring is the indispensable base for audit and evaluations. Audits are best known in relation to financial accounting and we can develop an understanding of the term as it may be used in environmental management by analogy. There are important differences between audits, comprehensive audits, and project and/or program evaluation. *Audits* are a searching examination of accounts; they ensure that financial histories accurately represent the performance of an organization. In that sense an *environmental audit* would do little more than

catalogue and verify the actual effects of a project, or, to put it another way, collate the results of monitoring.

Comprehensive auditing goes an important step beyond normal auditing. It asks whether appropriate procedures are in place to carry out the mandate of the organization. It also examines compliance with those procedures. The test of adequacy, appropriateness, and compliance can be given narrow or broad interpretations, leaving some room for creativity in the definition of subject material. In respect to organizations, comprehensive audits may examine personnel issues, procurement systems, even records management practices.

A *comprehensive environmental audit*, or *post-development audit*, the term used by Rigby (1985), would relate the actual effects of a project to the predicted effects of the project and whatever mitigation measures were undertaken. On the basis of scientific evidence, it would define and analyse the causes of variance between the actual and the expected. The subject of the audit is both the project and the EIA. An audit is, so far as possible, free of value judgments. Audits can be single or periodic events. In this paper, the term "audit" is used to refer to a comprehensive environmental audit as discussed above.

Evaluation is aimed primarily at questions of effectiveness. As a development of financial accounting, it asks whether the procedures examined by the comprehensive auditor have achieved the objectives set by the policy maker. It looks at all of the results of a program or project and compares them to the previously defined policy goals. In this sense, evaluation develops a causal analysis of program effectiveness. Its purpose is to find out what happened and why, and to provide the basis for judgment about the desirability of the results. If well done, it should delineate changes which would make results more in harmony with policy goals.

An *environmental evaluation*, or *hindsight evaluation*, the term used by O'Riordan (1971), would interpret the results of a comprehensive audit with reference to the objectives of the project and/or the assessment. Taking further account of the results of the audit, and on the basis of public consultations, it would re-examine and perhaps redefine the values attributed to elements of the environment, to social structures and their functioning at the time of project approval, and to the expected outputs of the project. An evaluation is undertaken in the light of policy and may result in further evolution of policy. It is based on more than scientific evidence, although it may be limited by the availability of scientific evidence. It is not value-free. Evaluations can also be single or periodic events.

THE NATURE OF EIA

While the definitions of environmental impact assessment indicate that many sorts of policies and activities may be assessed, EIA in practice is very much limited to specific projects. In practice also EIA seems to have been a highly variable procedure. This is a reflection of several factors, perhaps the most important being varying administrative requirements.

EIA may comprise a number of activities, some of which, such as baseline studies, monitoring and mitigation are often referred to separately. We prefer to consider EIA as a comprehensive term including the following:

- scoping,
- collecting and interpreting baseline data,
- predicting the effects of development and comparing them with expected conditions in an undisturbed state,
- evaluating the effects of development,
- proposing modifications to project design,
- proposing mitigating measures,
- proposing monitoring and other follow-up activities,
- reporting,
- monitoring effects of development.

Although the foregoing activities are initiated sequentially, certain steps may be repeated, wholly or in part, as there is information feedback from subsequent steps.

As experience with environmental phenomena has accumulated, it has become clear that instability is such a sufficiently common characteristic of ecosystems, as it is indeed of economic systems, that it is only prudent to expect and prepare to benefit from the unexpected. Adaptive environmental assessment and management (Holling 1978) is an approach that reflects that and other new perceptions and is beginning to be reflected in EIA (Jones and Greig 1985).

In seeking to judge the effectiveness of EIAs and their acceptance by decision makers, answers should be sought to the following questions:

- Do projects for which EIAs have been undertaken give rise to fewer and less severe environmental problems than similar projects that were not the subject of impact assessment?
- Are EIAs and environmental issues increasingly an integral part of the development and planning process or are they a marginal consideration?
- Are processes for mitigation of adverse environmental effects identified by assessment built into the project during its early stages or are they only a later add-on?

Individual audits and a comparative study of audit results can help to answer those questions.

THE NATURE OF AUDITS

Few audits have been undertaken and reported and those that have, emphasized different aspects of EIA. For example, some have been concerned mainly with mitigation, some with

administrative procedures and some with assessing the precision of predictions. Thus, there does not seem to be an established methodology for audits, but we suggest the process should consist of the following steps:

- review EIAs to identify
  - — predictions or forecasts or effects or impacts that are verifiable,
  - — recommendations of mitigation measures,
  - — recommendations for monitoring, surveillance or other follow-up,
  - — evidence of the administrative procedures and institutional relations that surrounded the assessment process

  (this step is analogous to scoping);
- examine records of monitoring, surveillance, and evaluation and commission special investigations if baseline data are not complemented by monitoring data;
- examine records relevant to mitigation measures;
- consult publications and reports on similar projects;
- interview persons involved in project, monitoring, etc.;
- collate and analyse data;
- subject analyses to peer review;
- report.

The precise characteristics and methodology for an EIA audit must, of course, be related to the structure and characteristics of the EIA itself and to the availability of relevant data. If baseline data are lacking or inadequate and if the EIA lacks precision, the audit will be difficult to undertake and its results probably unsatisfactory. If, in considering the scope of an audit, it becomes clear that the relevant EIA does not provide a useful basis for an audit, there is little point in proceeding further.

The purpose of audit (and evaluation) is to learn from experience. Audits should cast light upon the following points:

- the accuracy of EIAs as forecasts of the environmental consequences of a project,
- the effectiveness of recommended procedures for mitigation of the adverse effects of projects,
- the utility of recommended regimes and techniques for monitoring and surveillance,
- the effectiveness of procedures for environmental management of projects.

Evaluation, being a more comprehensive process, should extend the usefulness of examining experience to the level of policy.

These matters are discussed further in Chapter 3 and 4.

CHAPTER 2: OVERVIEW OF EIA AUDITS AND EVALUATION

THE BEGINNINGS

While the notion of formalizing a learning process by requiring that EIAs be subject to later audit or evaluation is not yet widespread, the roots of the idea are well established. After-the-fact assessments of anthropogenic change, of which there are many examples, not only laid the basis for EIAs but also demonstrated the importance of evaluating developments after they become operational. Examples of these less formalized evaluations, most often undertaken by academics, include analyses of man's impact on the environment based on paleontological evidence and the records of history, studies of landscape change based upon comparisons of old and modern maps, and comprehensive evaluations of some of the mega-projects of the present century. None of these examples is actually an audit of a formal environmental impact assessment, but many examine the assumptions implied in decisions to bring about some sort of environmental change and thus reflect the sort of thinking that led to the notion of environmental audit.

One of the earliest comprehensive analyses of the changes in the environment resulting from human action was by Marsh (1864). He not only traced the causes of different environmental impacts but also suggested protective and mitigative measures and stated the need for more careful development practices. The formidable and comprehensive assemblage of information under the editorship of Thomas (1956) was primarily directed toward the assessment of mankind's impact on the environment. The authors cited many examples of apparently unintended consequences of environmental interventions to demonstrate that our understanding of ecosystems was inadequate. Many of the faults in planning and executing projects resulted in unwanted, adverse consequences which, in retrospect, raised serious doubts about the overall values of the projects concerned. A modern work similar to Marsh's but in a much more sophisticated and quantitative idiom, is that of Goudie (1981).

Two powerful demonstrations of the potential of audit are by Warwick and Wilkinson. Warwick (1978) used sediment records to assess environmental impacts over several millenia and historical analysis to link the geophysical record to patterns of human habitation and economic activity. Another long time-line study is Wilkinson's (1977) historical study of the Aflaj of Oman, an audit of environmental theory and assumptions spanning 2,000 years.

Farvar and Milton (1972) edited a provocative collection of case studies of development projects in which they proposed and documented the theme of a "careless technology" by examining the negative implications of many projects, particularly dams. While they concentrated on the ecological costs of those projects, Bryant (1982) and several others have shown that other aspects of such projects may also be beyond the control of planners and managers. Even the economic benefits, generally seen as the driving force for projects and the yardstick against which ecological costs are measured, often fail to come up to expectations. Havemen (1972) discusses the economic aspects of some projects in the United States.

During the 1960s and 1970s, an extensive series of studies was made on "man-made" lakes (Lowe-McConnel 1966; Rubin and Warren 1968; Rubin 1975; ICOLD 1978; Panday 1979; Goodland 1979). The United Nations has held a major conference on water management issues in each of the last three decades. The first took place in 1958 and dealt with management of integrated river basin developments. In 1969, Unesco sponsored a conference in Paris on "status and trends in research in hydrology", at which management of land and water resources associated with hydrological cycles was an important element. In 1975, the UN Development Programme convened a conference at Budapest to discuss policies and planning for river basin and interbasin development (United Nations 1958; Unesco 1969; UNDP 1975).

The UNDP Budapest conference, in particular, heard many papers describing *ex post facto* evaluations of projects and development programs in various parts of the world. (See especially: Duckstein 1975a; Rubin 1975; Ballo and Orloci 1975; Bokhari 1975a, 1975b; Scudder 1975; Ress 1975; Mageed 1975; Futa 1975; Lwehabura 1975.) Few of those analyses involved specific tests of planning assumptions. Some emphasized the historical development of planning processes; others essentially described a normative model. The concept of rigorous audit or evaluation as defined here had not clearly emerged at that time. A few of the papers adopted a critical perspective on the planning and development process and posed in general terms some of the questions which are now taking more precise shape (see especially: Mageed 1975; Macinko 1975; Bokhari 1975a, 1975b).

Macinko (1963, 1975) conducted useful historical analyses of the development of the Columbia River in the United States. Sewell (1964, 1966) reviewed the Columbia River Treaty between Canada and the United States, which dealt with prospective developments in Canada. He concluded that insufficient attention had been given to social and economic issues. A critical evaluation of large multipurpose dams in 44 countries was undertaken by Bryant (1982). The study was primarily a test of the existing planning model and treated environmental assumptions as one of several major categories of concern. Environmental science was rarely fully used in the planning stages of the projects analysed, and the conse-

quences, particularly in tropical climates, were often so severe that the entire value of the project was brought into doubt.

Several analyses have been concerned with the human ecology of development projects. Scudder (1972, 1975) and Colson (1971) examined the consequences of human resettlement in an ecological sense. Schaffer (1974) analysed the community leadership aspects of various environmental changes. (See also: Schermerhorn (1974) on the Boise development; Benedict and Wasserman (1972) on the Brandywine.)

Other studies which involve evaluations of environmental aspects of development include: Oglesby, Carlson and McCann (1972) on mankind's effects on river ecology; Baxter and Glaude (1980) on the environmental effects of Canadian dams; and Carruthers, Clayton and Hamawi (1974) on the implementation and consequences of agricultural development at Wadi Dhuleil, Jordan.

The literature shows a weakness in the science upon which environmental management and the involvement of EIA in the development process is based. The view that ecology is in its early stages is strongly held. Willis (1975) made that point in the United States. Efford (1975), Rosenberg *et al.* (1981), Beanlands and Duinker (1983) and Hecky *et al.* (1984) have echoed it in Canada. The passage of over a decade since EIA became commonplace has, if anything, reinforced a sense of the immense scope of the unknown. Knowledge of the factors affecting the operation of ecosystems may be vast, but it is still far from being complete enough to permit the construction of accurate causal models. Without such models, it is not likely that the effects of environmental disturbances will be forecast accurately. We simply do not know all the implications of many complex cause-and-effect relationships.

A retrospective assessment of forecasts which Resources for the Future has published in relation to resource development and depletion found that some of the forecasts had turned out to be fairly accurate, while as many had proven to be well off the mark (Clawson 1985-i).

The record of post-project surprises is so long that some observers have considered all large-scale development projects to have fundamentally unknown and therefore uncontrolled effects. Omo-Fadaka (1978) states this position clearly and Bryant (1982) gives a lengthy catalogue of similar expressions of opinion. It has become a popular political position in some circles, and one which is difficult to refute successfully. Examples of the debates engendered are given by Dolan and Maestro (1975), Johnston (1976), Friesema and Culhane (1976), and Bardach and Pugliaresi (1977).

Black (1975) took a different view, arguing that environmental forecasting is no less accurate than that in other fields, such as economic forecasting, which serve as the technical bases for public policy. (The weaknesses of economic forecasting are legendary; Ascher (1978) provides a ruthless assessment of the empirical weaknesses of forecasting techniques.)

Willis (1975) saw the problem more as a mismatch of the quality of data available and the needs of the policy process, without prejudging the direction of the mismatch. Knetsch and Freeman (1979) have pointed to the same ill fit between the EIA and the decision process, charging that EIAs have been ineffective as a result.

The literature also shows that there have been important trade-offs in respect of some projects, and attempts have been made to evaluate some of them. George (1972) and Hafez and Shenouda (1978) have come to largely opposite conclusions about the balance of costs and benefits of the Aswan High Dam. Relics of ancient history and raw material for archaeology were sacrificed. So too was the traditional land of the Nubians and their life style. In return, Egypt gained water for irrigation and power. New areas of land downstream were brought into production. Additional costs have since had to be met as a result of widespread land degradation through salinization; loss of nutrients through elimination of annual, flood-drive resiltation; and the problems for agricultural workers due to the spreading of bilharzia and other diseases through the enlarging canal system.

The opposing conclusions of George and Hafez and Shenouda depend to a great extent on differing values placed on such intangible factors as national self-image. Indeed, it would be crucial whether a modern or traditional self-image were considered to be the most important. While it is clear that great costs can be incurred, it is not as clear, if such costs had been forecast, to what extent they would have been acceptable exchanges for intangible national benefits. Such issues are very much the substance of broad national policy. How many of the eventual costs (the above list is only partial) were recognized when the project was approved? How well were those costs measured and compared to the expected benefits? What have the benefits really been worth? We don't know the answers to those questions and they involve comparisons beyond scientific methodologies. Yet human beings make judgments about such matters. We look back and form an opinion of the overall value of a project like the Aswan High Dam. And we look ahead at the possible consequences of implementing proposals such as that to dam James Bay and divert waters to the south, and that of the North American Water and Power Alliance (Parsons 1964) and form a summary judgment. What criteria are used? How are they weighted? Is there something common enough about those fundamental individual and social judgments that can be captured, calibrated, modelled? These are questions that have been raised for decades, if not centuries. The answers remain uncertain today.

RECENT AND CURRENT AUDITS AND EVALUATIONS

The evolution of environmental audits and evaluations has been lengthy and there is no seminal event that marks the advent of an era of formalized and sophisticated audits and evaluations. But with the passage in the United States of the National Environmental Policy Act (NEPA) (1969) and the formalization of the process of environmental impact assessment, it was perhaps inevitable that increasing attention to audits would soon follow. That, in fact, is what has happened

and during the past five years in particular there has been an increase in the number and quality of both audits of specific projects and more general evaluations of the assessment process. Yet only in two instances, apparently, — in two of the Australian states — has a requirement for audit been institutionalized. In view of the attention currently being given to the process, other jurisdictions may follow that example.

Examples of recent and current activity in several countries and international organizations follow.

Canada

The evolution of EIA in Canada has been outlined by Boothroyd and Rees (1984). In the early 1970s it was dominated by a technocratic perspective: "The assumption was that complex environmental and social systems are completely knowable." But the efficacy of EIA as first practiced was soon questioned and its recent and continuing evolution may lead to EIA being seen as a "major component of the development planning process."

EIAs are undertaken in response to the requirements of both the federal and provincial governments and each government has established institutions to manage them. A prominent role is played by the Federal Environmental Assessment Review Office (FEARO) which oversees the Environmental Assessment and Review Process (EARP). With FEARO, the Environmental Protection Service (EPS) of Environment Canada has begun to give useful attention to audits.

An important recent innovation has been the establishment of the Canadian Environmental Assessment Research Council (CEARC). Its broad base (federal and provincial governments, private sector, and universities), its independence, and its comprehensive mandate hold exceptional promise. It is important to have an independent, broadly representative body to identify and address the complex issues that arise as the process of EIA evolves. The interacting, organizational, technical and political issues now on the agenda are unlikely to be resolved by the institutions established to deal with the seemingly more simple EIA issues of the 1970s.

A major review and evaluation of EIA in Canada, undertaken by Beanlands and Duinker (1983), was sponsored by FEARO, Dalhousie University and two important industrial associations. The study implied the need for audits in emphasizing "the importance of continued study beyond the production of an EIS" and strongly recommended monitoring as an integral part of assessment.

Several conferences have helped advance the conduct of EIAs and EIA audits. In 1982, Environment Canada sponsored a conference on Environmental Monitoring of Federal and Provincial Projects, which dealt largely with governmental procedures and requirements. (Environment Canada 1983.) In 1984-85, a follow-up study was conducted (McCallum 1984) which included a survey of practices currently in place and their importance to project development.

At an international workshop on Environmental Planning for Large-Scale Development Projects (Environment Canada and Canadian Petroleum Association 1983) there was a session on approaches, tools and techniques at which a paper on audits was presented (Clark 1983).

A particularly valuable scientific study of the effects of a development project, that of the impoundment of Southern Indian Lake and the diversion from the lake of the Churchill River, was undertaken by teams from the Freshwater Research Institute and reported by Hecky *et al.* (1984).

Early in 1985, as noted earlier, EPS in collaboration with a number of development project proponents commissioned and provided financial support for "follow-up studies of the environmental aspects of projects after implementation". Together with about 30 similar studies, they were discussed at a Conference on Follow-up/Audit of Environmental Assessment Results later in 1985. The follow-up studies considered both technical and procedural/administrative factors. They were aimed at accumulating knowledge that would advance the state of the art of environmental assessment in Canada.

United States

In the United States, reliance upon the adversarial system and the threat of litigation to ensure compliance with the requirements established by environmental impact statements (EISs) seems to have detracted from moves to undertake audits or evaluations (Stoel 1985-i; Printz 1985-i). The federal regulatory process, administered by the Environmental Protection Agency (EPA), has no significant audit component. While EPA has an administrative unit that keeps track of EISs, it does not seem to have a significant role in quality control or improvement. The Council on Environmental Quality (CEQ), which promoted the development of environmental impact assessment during the 1970s, has been much less active in recent years.

The Natural Resources Defence Council (NRDC) and other environmental groups were quite successful in litigating compliance with the National Environmental Policy Act (NEPA) (1969) during the 1970s. Now NRDC does not keep a close watch on compliance, believing that past interactions and the threat of further litigation will be sufficient to ensure adequate performance. Actual tests of performance are not being conducted.

Similarly, the emphasis at the U.S. Forest Service (Wenner 1985-i; Fitzgerald 1985-i) is on producing correct guidelines, rather than on auditing compliance or testing the performance of the guidelines. The General Accounting Office (GAO), the U.S. federal leader in performance measurement and evaluation, does not seem to have addressed the environmental assessment issues which FEARO and EPS are currently examining in Canada.

United Kingdom

In the United Kingdom environmental considerations related to development are taken into account mainly through what is termed organic or integrated planning. There is no requirement for a detailed study of the impacts of development: EIAs are made on an *ad hoc* basis. As in some other jurisdictions, there

is an emphasis on codification of procedures and guidelines and there is a clear policy of incorporating sound environmental procedures into the planning process, with the presumption that everything will then work well (Jacobs 1985; UK Foreign and Commonwealth Office 1983; UK Department of the Environment 1984).

Despite a general preference for believing that sound environmental principles should be built into the planning process and that EIAs are not required, there have been some EIAs of major projects that required consideration beyond the scope of regular planning. Similarly, although it is believed that there is little need for post-project audits, there have been audits of several North Sea oil and other industrial projects.

Studies undertaken by the Centre of Environmental Management and Planning of the University of Aberdeen have substantially advanced the practice and theory of environmental audit (Bisset 1980; Clark 1983).

Roberts and Roberts (1984) compiled several articles on the interaction between planning and ecology, as discussed at the 1980 symposium of the British Ecological Society. One section of their book addresses post-project monitoring, primarily in terms of evaluating the accuracy of the predictive methodologies used to make pre-project assessments.

Australia

In Australia analysis of EIA has largely focused on the institutional and legal aspects of existing regulations and their administration, and the Fowler Report (1982), which is an analysis of those components of the Australian systems, remains the central piece of analysis and the focus of discussion (Robertson 1985). There do not appear to have been any evaluations of results of regulation (Jakeman 1985). Although New South Wales has apparently established EIA audit requirements, and Western Australia has implemented an ongoing system of regular Environmental Review and Monitoring Programmes (ERMP) (Robertson 1985), their nature and impact have not yet been ascertained by us.

World Bank

The work of the World Bank is very important since its impact on development is felt directly throughout the Third World and, in addition, its approaches and practices provide an example to other organizations. The World Bank has been a leader in evaluation through its Operation Evaluation Division (OED) (Balasse 1976; Bryant 1982; Weiner 1984). In the past, the Bank's evaluation process has been almost exclusively concerned with economic and financial aspects but, more recently, new approaches including participation of host country personnel (Weiner 1984) and five-year-after general reviews of projects (Donaldson 1985-i) have resulted in increased attention to wider concerns. The OED is uncovering a substantial number of environmental impact concerns in the five-year-after evaluations (Donaldson 1985-i) but there are some doubts about the timeliness of systematically addressing the issue now. This is at least partly a reflection of the debate between the more advanced and the less industrialized countries about the true social costs and benefits of environmental quality at different stages of economic development.

The Bank's Office of Environmental Affairs (OEA) is involved primarily at the design stage of projects (Goodland 1985-i; Lee 1985-i), but it has become involved in project assessment and has established the principle of incorporating mitigation costs in project design and bank loan support. It has not been fully effective in getting local assessments to measure up to generally accepted scientific standards. Follow-up research is largely dependent on the initiative of individual staff members. While the research is outstanding, it is a small effort in comparison to the magnitude of the Bank's involvement in project development.

One of the leading analysts of the sociological consequences of development projects has been Scudder of the United States (see, for example, Scudder 1972 and 1975). The issue of population movement and resettlement associated with development projects has come to assume greater emphasis in many countries. In some projects, the funds set aside for resettlement now equal those for the construction itself (Goodland 1985-i). The World Bank, at least partially in response to the pressure from some members who have now lived with the consequences of haphazard resettlement schemes for a decade or more, has put a lot of emphasis on these human factors in its project planning.

While the Bank continues to be involved in many projects, it is moving increasingly into sector-based support and institutional development (e.g., the Public Enterprise program, Donaldson 1985l). That raises some concerns about future opportunities within the Bank to address environmental issues which are project-specific. It may be that the value of the experience to be gained from the Bank's many projects will have to be developed outside the institution. In that case, non-governmental development organizations or academics may have to carry the burden. There will, of course, be more opportunity to establish country-wide or sectoral environmental policies as the Bank shifts to a sectoral or institutional focus. Unfortunately, environmental concerns seem to be stimulated primarily by specific projects; a reduction of project-level activity is therefore likely to lead to reduced attention to environmental issues, at least within the framework of the current priorities of the principal decision makers in client countries.

United Nations Economic Commission For Europe (ECE)

Organization for Economic Co-operation and Development (OECD)

The ECE's group of Senior Advisors on Environmental Problems has constituted an expert group on EIA. In considering the frameworks and methodology of EIA, ECE has given considerable attention to audit and evaluation, using the term "post-project analysis" (ECE 1982). ECE and OECD are currently undertaking a six country study to compare the EIA techniques in use. In each country, including Canada, case studies are being conducted on roads and water management projects (Runnals 1985-i).

CONCLUSIONS

There have been few deliberately planned audits of EIAs, but there are many studies of environmentally important projects that have some of the attributes of audits. There do not, however, appear to have been comprehensive reviews of the findings of these quasi-audits, comparing them with models of ecological change to test and improve the models.

There is ample evidence that worthwhile audits can be conducted. The earliest audits were probably the most difficult ones since they referred to assessments which were not designed with an audit process in mind. But the assessments themselves have progressed now to the point where for many of them sufficient basic information to support an audit is available. Certainly it should be possible to undertake future assessments in such a way that audits could be made later without undue difficulty.

Different jurisdictions have adopted many different approaches to environmental management. There appears to be a widespread faith in institutionalized processes, with only a minority seeking evidence of the effectiveness of those processes. The current FEARO/EPS project is clearly a trail-breaker because it does seek such evidence, and does so on both the scientific and procedural level.

CHAPTER 3: SCIENTIFIC AND TECHNICAL ISSUES ARISING FROM EIA AUDITS

THE ROLE OF SCIENCE

Environmental impact assessments are undertaken to assist the people who make and implement decisions about development. Science, specifically ecology, constitutes the underpinning for EIAs and it must play a significant role in their design and execution. But EIAs are not made to advance science, even though the knowledge obtained in the course of assessments may have that effect. Similarly, while audits are undertaken to assist in evaluating processes and decisions in which science has played a role, the information that is yielded by audits can be used to improve their scientific and technical components.

Scientific considerations are of major importance in planning and undertaking baseline studies and monitoring and in the process that lies at the heart of EIA, predicting the consequences of development on the constitution and functioning of natural systems. Technical skills are important in measuring and recording environmental characteristics and phenomena and in designing and carrying out actions intended to mitigate the adverse effects of development.

In practical and immediate terms, the most important result of an EIA, unless it leads to the cancellation of the project, is the design and implementation of measures to mitigate adverse environmental effects of projects. This is why, as most of the case studies clearly demonstrate, the opportunities for elegant environmental experiments that might be expected to result from development projects are often masked, if not completely obliterated, by mitigating actions. One can almost hear the project manager say, "We're not here to do science; we're trying to do the most cost-effective job of managing the environment."

There are a number of important questions about the scientific and technical aspects of EIA that audits should be expected to answer. The scientific questions are:

- Were sufficient baseline data acquired?
- Was effects monitoring properly planned and undertaken?
- Were the major effects of development correctly identified?
- Were the direction and magnitude of the effects adequately forecast?
- Were multistage and cumulative impacts correctly predicted?

The technical questions are:

- Were the mitigation measures proposed as a result of the assessment undertaken?
- When mitigation measures were undertaken, were they effective?

Scientific issues, as yet unresolved, have an important bearing on the extent to which audits can be expected to provide the answers to those questions. The main issue is the degree of precision that is possible in assessing and predicting environmental parameters. To the scientific issue of how accurate is the prediction likely to be, can be added the operational question of how accurate it needs to be and other questions about the technical feasibility of proposals for mitigation. There is also a question about the usefulness of auditing predictions that are imprecise. Finally there are questions that arise from the relationship between a prediction, a mitigating action, and an audit. The intent of a mitigation is to reduce the impact of a project or, put in another way, it is intended to invalidate the prediction. So what then is the purpose of the audit? It may assess the overall, post-mitigation effects of the project but, unless another set of predictions is based on the likely effects of mitigation, the audit cannot assess the accuracy of prediction.

Questions relating to the accuracy and precision of predictions and audits will be explored in more detail after examining the evidence acquired through audits under the headings baseline studies and effects monitoring, prediction and mitigation.

BASELINE STUDIES AND EFFECTS MONITORING

It is these two scientifically based activities that enable accurate assessment of environmental impacts. They also provide the basis for audit of prediction and mitigation. The importance of both activities has been emphasized repeatedly in the literature (e.g., McCart 1982; ECE 1982; Beanlands and Duinker 1983) and again by the authors of the follow-up reports. As Jakimchuk *et al.* (1985) put it: "Continuing public and agency concern has resulted primarily from inadequate verification of potential impacts and the effectiveness of proposed mitigative measures." Kiell *et al.* (1985) say practically the same thing and add, "...EEM (environmental effects monitoring) ...should be an integral part of EIA." Monitoring of stream conditions near pipeline crossings in southern Ontario "increases (the) data base and helps the assessment ..." according to Moncrieff *et al.* (1985)

It seems self-evident that both baseline studies (pre-project monitoring) and effects monitoring are essential to any managerial function. How can you manage any enterprise without knowing the relevant conditions when you begin and without checking on the results of your actions as you go

along? Yet the fact often is that neither baseline studies nor monitoring are undertaken or, if they are, they are inadequate or begun too late.

The first studies of the social and environmental effects of the James Bay hydro-electric project (La Grande complex) were undertaken by native groups, funded by the federal government, only after the project was initiated. The consequent evaluation of the impacts of the project on the life style of the Cree and Inuit was reflected in the James Bay and Northern Quebec Agreement. Subsequently, but before improvements and diversions became operational, a comprehensive program of baseline data collection was initiated and systems models were developed and tested in an effort to improve prediction (Roy *et al.* 1982; Rosenberg *et al., in press*). Follow-up studies are underway (Roy 1985-i).

Zallen *et al.* (1985) concluded that the residual impacts of pipeline construction in the Coquihalla Valley would never be fully identified since no formal monitoring programs were undertaken. Hecky *et al.* (1984) state that the major lesson from Southern Indian Lake is that the current approach to assessment, which is largely a pre-development activity, is incomplete and unacceptable: predictions should be recognized as planning aids that require testing in the post-development period to establish their veracity and complete the environmental assessment process.

Unless no baseline data are obtained before the project is begun, the major problem is that too few data are gathered, sometimes because the period of data collection is too short, sometimes for other reasons. In any event, if too few data are obtained, there is no assurance that the inherent variability in certain parameters will be satisfactorily defined. Thus it will not be clear if variables detected after the project are within the range of natural variability or are the result of the project. Ruggles (1985) stated that no amount of post-development sampling could make up for the lack of a suitably precise pre-development estimate of juvenile salmon abundance: at least ten, rather than six, population samples should have been taken.

On the other hand, it is possible to accumulate too much rather than too little information. The follow-up study of the Rivière-des-Prairies spillway reconstruction project showed that more information was obtained than was actually needed for proper effects monitoring (Karpinski *et al.* 1983). It was concluded that it may be easier to carry out baseline studies than to use the information creatively to optimize management planning (Karpinski 1985-i).

In their review of three hydro developments in Newfoundland, for which EIAs were submitted in the period 1978-1980, Kiell *et al.* (1985) note that the proposed monitoring programs were vague and emphasized environmental compliance rather than environmental effects monitoring. Experience with the first two projects led to the preparation of an addendum to the EIS which eventually resulted in a more clearly defined and effective monitoring program. The investigators concluded that monitoring programs should be identified and designed early in the EIA process, that they should be carefully selected (not all impacts need to be monitored), and that they should be designed and conducted as scientific studies. Kiell *et al.* also speculated that the necessity to concentrate on compliance monitoring, which was often related to environmental concerns in respect of which there are enforceable regulations, may have diminished the attention given to valued ecosystem components not protected by regulation.

A wide range of monitoring activities was carried out during the twinning of the Trans-Canada Highway in Banff National Park. They included surveys of road kills and of the use of underpasses and the effectiveness of fences in influencing the distribution of wildlife. This type of monitoring, which might be termed "operational monitoring", was evidently most useful in modifying design and siting during the construction period.

Everitt and Sonntag (1985) state that biophysical sampling procedures and statistical techniques are not sufficiently developed to determine conclusively that changes have occurred as a result of a development activity. To the extent that their statement relates to baseline studies and effects monitoring, and we would expect that it very largely does, we would agree that it is true. We would add that it remains important that the project planning and management process allows for the effective application of sampling procedures and statistical techniques that now exist. It is only through continuing field experiments that these procedures and techniques will be improved.

While we noted earlier that some studies based on the interpretation of historical data could be considered as the precursors of evaluation or audit, no future audit or evaluation of a project is likely to be credible unless it is founded on baseline and monitoring data. But simply to state a broad requirement for baseline and monitoring data is not sufficient.

Monitoring must be undertaken in accordance with a plan that reflects:

- effective scoping in accordance with the concept of valued ecosystems and the likelihood of change in ecosystem components,
- a strategy and design to ensure that the information acquired is relevant to perceived issues, and reflects conditions over an adequate period of time,
- the need to establish statistically acceptable conclusions.

PREDICTIONS

The sense of the case studies and, indeed, of the current literature on environment and development (Goodland 1985-i), is that environmental assessment techniques, if properly applied, are adequate to identify, if not precisely forecast, almost all of the major environmental implications of projects. There are, however, areas of imperfection which detract from the general sense of satisfaction.

The most noticeable characteristic of environmental predictions is their imprecision. Few are quantitative. The majority are qualitative and employ phraseology that is tentative and uncertain.

Among the reports of the case studies that we have had the opportunity to review, only for the Wreck Cove hydro development was there a quantitative prediction: the mean monthly flows of the Cheticamp River after the project was constructed were forecast in m3/sec. Predictions of other changes expected as a consequence of the Wreck Cove development were couched in qualitative terms. Changes in nutrients, pH and primary production were expected to show a noticeable, very slight, slight, large or very large increase. It was also predicted that the "salmon resource would not suffer" (Ruggles 1985).

In considering the effects of highway construction in the Coquihalla Valley, there is no clear statement of the potential magnitude of impacts; they are noted as "minimal" or "severe", and those terms are not defined. Some indication of magnitude was conveyed by specifying the areas of habitat potentially lost (Zallen *et al.* 1985). Impacts of the Shakwak Project on fisheries were predicted as "will be negligible", or "could enhance"; for vegetation there could be "a reduction" or "an increase" (Spencer 1985). Three EISs for hydro projects in Newfoundland were "relatively simple descriptive documents with little attempt made to quantify predicted impacts" (Kiell *et al.* 1985). Impacts of twinning the Trans-Canada Highway through Banff National Park were expressed as "concerns", e.g., "concern that ... motorists ... could encounter features ... that offended the overall visual impression" (Janes and Ross 1985).

Pre-impoundment predictions for Southern Indian Lake, while qualitative, are expressed in greater detail and with more confidence, e.g., "No thermal stratification," "Deoxygenation only in immediate vicinity of flooded soils," "No increase in offshore primary productivity over most of lake; probably lower primary production nearshore on exposed areas of high wind fetch. In protected areas with high transparency, production will increase in the short term" (Hecky *et al.* 1984).

The fact that predictions are usually imprecise does not mean that they are not useful. They must have been of some use since the case studies suggest that there were no major disasters as a consequence of any of the projects undertaken. It is not clear, however, that we know enough about long-term environmental reactions to presume that projects currently judged to be environmentally acceptable are likely to remain so forever. Some of the concerns with chemical waste disposal, for example, have arisen as a result of underground flow patterns which were not sufficiently understood to cause concern thirty years ago. The fact that such ecological problems as acid rain and mercury poisoning continue to emerge suggests that the door has yet to be closed on that sort of environmental problem which is ignored for years, then is "discovered" to have had serious implications all along.

The impreciseness of predictions does make them difficult to audit with any degree of confidence. What is a "slight reduction"? What are "minimal effects"? These are not the sorts of predictions that can be scientifically assessed with any degree of precision, although they may be satisfactory for operational purposes.

In addition to impreciseness, there is the question of general accuracy. In the case of the James Bay project, predictions of major ecological change were generally well established, but as more detailed information is being accumulated some predictions are found to be incorrect (Roy 1985-i; Rosenberg *et al., in press*; see also Berkes 1982). In the Coquihalla Valley, the construction of a pipeline "appeared to result in a greater amount of sedimentation than predicted". What was predicted was that the effects of sedimentation would be minimal. It has been suggested, however, that sedimentation was more than minimal, it may have been enough to affect one year-class of steelhead by reducing egg-to-fry survival. Evidence on the fate of this year-class not yet available may eventually clarify the situation (Zallen *et al.* 1985). Of the 19 predictions of the impact on fisheries of the Shakwak project, only 4 could be supported or refuted; there was insufficient information to quantitatively assess the reliability of the predictions. The impact predictions for vegetation were "soft" and not conducive to quantitative post-project evaluation (Spencer 1985). Dorcey and Martin (1985b), in the review of case studies of the Utah and Amax mines, report that for Utah, 4 out of 10 impacts were correctly predicted, and for Amax, 14 out of 15. In his major review of EIA predictions in the United Kingdom, Clark (1983) found that 43 out of 76 predictions that could be audited were accurate. Fifteen predictions were made for Southern Indian Lake, of which 13 were correct; 7 post-project phenomena were unpredicted (Hecky *et al.* 1984). One of the inaccurate predictions rested on a failure to predict a behavioural reaction of lake whitefish, which were thought to require shallow water over rocky bottoms for spawning. It was feared that they would not find a suitable site immediately after impoundment but they continued to spawn on their original sites at greater depths.

The Southern Indian Lake Study is instructive in its suggestions of the reasons for errors in specific predictions. It suggests that existing models of environmental responses were much too limited in their consideration of major systemic factors, such as the effects of heat impact, erosion and leaching on trophic activity, turbidity, temperature, etc. If the basic paradigm or systems view is faulty, then many of the parameter estimates it produces for application to species reproductive rates, for example, will also be faulty. The importance of the interconnectedness of the ecosystem is reinforced as an explanation of the mistaken predictions of minor elements of it.

The nature of cumulative effects is receiving increasing attention. The study of the Coquihalla is particularly interesting because it deals with the construction and operation of a railway (in 1916), three pipelines (in 1953, 1957 and 1979), and a four-lane highway (begun in 1979) within a narrow mountain valley. In addition, a gold mine was constructed and operated for several years within the watershed and there has been a long history of logging. Zallen *et al.* (1985) note that the earlier transportation projects were not subject to EIA, although some attempt was made to minimize expected adverse environmental effects. Despite the multi-use pressures in the valley, little attention has been paid to cumulative effects, perhaps because they were not included in the terms of reference for EIAs. They may have been scoped out, but

they are clearly important. Environmental assessments do not appear to be required for logging, although it was suggested in several project assessments that logging has a significant impact on water quality through erosion and sedimentation.

In view of the paucity of information, it is imprudent to be categorical in answering the questions posed earlier, but the following conclusions seem appropriate:

- major effects have been correctly identified more often than not and so have their directions; errors in predicting the magnitude of change are common;
- multistage and cumulative impacts are correctly predicted less frequently if at all;
- the most satisfactory predictions relate to phenomena such as oil spills and temperate-climate reservoirs which have already been much studied and monitored, although there are exceptions;
- first-order effects (e.g., water quality, air quality, habitat loss) are the easiest to predict; second-order effects (e.g., primary productivity, population changes) the next; and higher-order effects (changes in animal behaviour and socio-economic effects) the most difficult; complex systems with many linkages are not usually well understood.

In view of the foregoing conclusions it is suggested that:

- opportunities be sought to improve knowledge and understanding of cumulative impacts, and
- research concentrate upon understanding of ecological systems and the changes that they exhibit rather than the simpler first-order effects of environmental disturbance or the more complex higher-order effects on human and animal behaviour.

MITIGATION

Some of the follow-up studies deal almost exclusively with the process and results of mitigation. The general sequence of activity that they reveal is assessment, identification of potential impacts in general terms, design and implementation of mitigating measures, reassessment and, if the potential impact has been avoided or minimized, adoption of the mitigating activity as a standard procedure in comparable circumstances. Predictions of the effects of mitigation are not usually explicit; most often it is simply assumed that they will result in improvement. If predictions are explicit they are couched in general terms. The indicators of success tend to be integrative, (e.g., fish populations have been maintained) or social, (e.g., highway design is considered aesthetically attractive) rather than analytical and scientific. Such indicators are satisfactory from an operational viewpoint but do not provide much basis for scientific audit.

Mitigation is an exercise in pragmatism: on the whole, it seems to have worked well and to have been well received. Many mitigations deemed to reduce adverse environmental impacts are minor modifications to construction procedures or operating regimes. For example, highway construction at stream crossing on the Shakwak project was scheduled to avoid periods when the impacts on fisheries would be most severe (Spencer 1985). In the Coquihalla Valley, the timing of construction was a key consideration in mitigating impacts on fisheries. Recommended construction periods varied depending on the type; schedules for some aspects of highway construction did not need to be as rigid as those for trenching for pipelines (Zallen *et al.* 1985). Many of the damaging effects to soil noted as a result of earlier pipeline construction in Southern Ontario have more recently been avoided by suspending the operation during wet weather (Moncrieff *et al.* 1985). The impact of construction noise at Rivière-des-Prairies was more or less tolerable during the daytime but "complaints were expressed when activities went on early in the morning or late in the evening". A tighter work schedule was considered the most appropriate noise mitigation measure (Verdon 1985).

Perhaps the greatest concern aroused by the Wreck Cove hydro-electric project was the expected impact on salmon of reduced flows of the Cheticamp River. Mitigation was achieved by devising and implementing a riparian flow policy to provide a base flow not lower than the one-year-in-four mean July flow. As indicated elsewhere, the evidence suggests that the policy was effective (Ruggles 1985).

In addition to scheduling, a number of relatively simple tasks, many of which represent no more than good construction practice, are important in mitigation. These include stabilizing disturbed areas by seeding and fertilizing or other means, selecting the direction to fell trees which is least damaging, restricting the operation of vehicles in streams, identifying and flagging trees for protection, topsoil stripping and replacement (Moncreiff *et al.* 1985; Spencer 1985). Good environmental performance on a project is a potent form of mitigation; it depends upon effective communication among all concerned, the attitude of the contractor and good construction planning.

As experience with particular types of projects accumulates, mitigation measures observed to be effective in reducing or eliminating specific impacts tend to become part of standard construction operations and may, in part at least, be reflected in operations manuals (Moncrieff *et al.* 1985). La société d'énergie de la Baie James (SEBJ) has developed such an operations manual. It was first used by on-site project managers for Hydro-Quebec's 315 kV Rivière-du-Loup hydro-electric transmission line project. The Rivière-du-Loup case study is presently being evaluated. In his review of the recommendations relating to three northern pipelines, Jakimchuk *et al.* (1985) noted a trend away from a detailed list of specific mitigative requirements and toward reliance on standard operating procedures and regulatory requirements. In the report on the Shakwak project, Spencer (1985) notes that "many environmental issues can be solved by applications of standard mitigation measures".

Some mitigations are and will remain site-specific, specialized activities. These include devices either to facilitate or prevent the passage of fish on the Shakwak project (Spencer 1985); sediment traps and barriers downstream of pipeline crossings (Moncrieff *et al.* 1985); and highway underpasses and fences

to control the movements of wildlife in the vicinity of the Trans-Canada Highway in Banff (Janes and Ross 1985).

Where mitigations have been audited, the results are expressed in general and pragmatic terms. In respect to the Shakwak, Spencer (1985) notes, "The construction program was generally successful in improving on the undesirable fish passage conditions that existed at crossing sites prior to construction... Mitigative measures were generally well followed. If it can be assumed that those mitigative measures would actually reduce potential impacts on fish, then the project should not have impacted on the fish resource. Revegetation efforts in the right of way were generally successful ... Re-spreading stoned surface soils ... prior to seeding and fertilizing is the best way to assure successful vegetation." Moncrieff *et al.* (1985) refer to controversy about the usefulness of sediment control devices, noting that the lack of quantitative and comparable data makes assessment of their effectiveness difficult and that more quantitative monitoring is needed. The animal movement control measures undertaken at Banff are not yet complete and evaluation is, therefore, tentative. Monitoring throughout construction has, however, enabled the detection and correction of design problems, e.g., some of the earliest underpasses were not used because of difficulties with snow and ice (Janes and Ross 1985).

Mitigation is at the heart of environmental management at the project level and the evidence of the follow-up studies is that it has evolved in a progressive fashion. Jakimchuk *et al.* (1985) summarize the situation well in stating:

- "Information availability and practical experience appeared to be the key factors that affected the evolution of recommended mitigative measures."

We may add as a general conclusion that:

- mitigation is frequently undertaken as a standardized or *ad hoc* operating response to perceived environmental concerns and there is often insufficient information available to evaluate mitigations.

We therefore recommend that complete records be kept of construction and operating experiences, particularly as they are adapted in response to new information and understanding gained in the course of the project.

ACCURACY AND PRECISION OF ENVIRONMENTAL SCIENCE

There is much evidence of the lack of accuracy and precision of EIA predictions and general agreement that better predictions would be worthwhile. There are perhaps two main reasons why better prediction is considered desirable. The first flows from the numerous examples of adverse environmental effects of development; it is assumed that they might have been avoided if they had been accurately predicted in a way that commanded credibility. The second reason is the human desire to improve performance; the need to predict is seen as a challenge to skill and knowledge. If environmental predictions were improved the expected benefits would be better environmental management and greater knowledge of the structure and functioning of ecosystems.

The two sorts of expected benefits are not incompatible but giving priority to one or the other can have significant operational and cost implications. If priority is given to improving the quality of environmental science, there will be an emphasis on procedures that will facilitate the experimental approach and ensure the collection of adequate and timely data. On the other hand, a prior concern with saving time and money and concentrating on "practical" measures is likely to mean that there will be less emphasis on precision and on scientific aspects of the work generally. What is most likely, of course, is that there will be continuing tension between the two approaches; they will be adopted concurrently so far as they can, but the emphasis will tend to swing from one to the other.

The question of what accuracy and precision one can reasonably expect from environmental prediction remains. For many of the projects which cause major environmental impacts, from five to fifty years or more may be taken up by planning, implementation, and operation. Since there is really no such thing as a completely closed social or ecological system, particularly over an extended period of time, it is unreasonable to expect a high level of accuracy from predictions. For example, the specific value of soil or water pH ten years after construction of a smelter could be the consequence of so many variables other than construction of the smelter that highly precise prediction would be imprudent. What is important is whether the pH is changing in the direction and magnitude predicted, whether it is likely to move into a range which holds serious implications for other parts of the ecosystem, and whether the factors affecting the process are well understood in that particular ecosystem. If the processes which underly changes in indicators such as pH levels are properly understood, then changes in exogenous factors will trigger expectations of change in the indicators and in associated secondary effects; it will be possible to take timely mitigative action. If those processes are not understood, the changes will come as a surprise, and mitigation will be more difficult or impossible because of the delay.

Some of the work conducted recently at the University of Aberdeen (Bisset 1980) has reached the discouraging conclusion that the design of projects and factors external to projects change so much between assessment and audit that comparisons become very difficult. An audit can take either of two approaches when faced with such a situation. In the first, it can reconstruct the planning model used in project design, then test it against the state of knowledge at that time. Alternatively, it can be tested against current standards so that (a) required revisions for current planning efforts are made clear and (b) trends in such changes may be scrutinized in the effort to establish their pattern (if any) and hence anticipate future changes. With such objectives, very useful audits can be conducted even in what appear to be highly variable, unbounded planning environments.

A discussion of forecasting techniques (MacDonald 1985) was strongly critical of the application of rigid or linear techniques to dynamic multifaceted phenomena. Ascher (1978), in his

critique of forecasting technologies and their misapplication, has made similar criticisms. Indeed, the purpose of many alternative forecasting techniques, such as system dynamics, is to avoid such flaws (Forrester, Mass and Ryan 1976).

Simulation methods, of which system dynamics is a particular variant, can be used to build both simple and complex models of interactive systems (Larkin 1984). Modular structures allow simple formulations of one part of a model to be replaced with more complex ones to improve resolution. Specific parameters, or even functional relationships can be adapted to specific systems, such as river basins. Other modelling techniques can be used in subroutines to estimate specific parameters at certain stages of the modelled system's evolution. As knowledge improves, simple structural relationships may be replaced by richer and more accurate depictions. The modular nature of many simulation models makes such changes quite straightforward.

But we must keep our feet on the ground. In a review of the lengthy controversy over the impact of electric power generation on the Hudson River striped bass populations, Barnthouse *et al.* (1984) cautioned that, "shortcuts to solutions cannot be found through elaborate modeling exercises... simple, empirical models designed to fit the available data are more useful than complex, process-level models that require unavailable data." Failure to draw definitive conclusions about long-term effects on fish populations was because of "insufficient understanding of underlying biological processes."

Physical scientists are used to a form of investigation which is based on clearly stated hypotheses and requires precise data to reach conclusions. Many social scientist have found that attempting similar precision may lead to absurdities. The level of present knowledge about the causes of human behaviour is such that social scientists often find themselves unable to achieve numerical precision when analysing broad changes. As a result, some have been led to concentrate on delineating the major structural patterns underlying behavioural phenomena. Until a higher level of knowledge is achieved, it is unlikely that more detailed prediction will achieve more than correlational accuracy. Even models based on fundamental structural phenomena are likely to break down when applied to situations containing functional features not represented in the reference data base. In other words, the paradigm must be appropriate.

Environmental science may be in much the same situation. From the analysis of Hecky *et al.* (1984) of the Southern Indian Lake experience, it appeared that the basic paradigm, derived over a period of years from investigations of reservoirs elsewhere, was appropriate for predicting some effects but not others. It was inadequate in its consideration of the nature of the area to be flooded and it failed to predict or predicted incorrectly responses above the primary trophic level.

The most famous analysis of paradigms and their role in the evolution of science, and especially their role in the definition of accepted scientific opinion, was developed by Kuhn (1970). Studies such as that at South Indian Lake suggest not only that an established paradigm exists to explain ecosystem perturbation and response, but also that there are several "loose ends" when that paradigm is tested. Following Kuhn's analysis of other scientific fields, the implication of those loose ends is that a new paradigm is in the offing, one which will incorporate present knowledge and solve some of the puzzles which the current model can't handle.

Some authors have assumed that if forecasts are to be audited they must include explicit statements of expected effects. Ideally, precision is preferable, but so long as precision is unattainable we take a different view. Clear, sharp forecasts certainly make an auditor's job easier, and are by no means without value, but they may in one sense be misleading. In the current state of environmental science, if such predictions are to be expressed within the usual bounds of scientific confidence, they must be relatively limited in scope and complexity. As a result, they may be too narrow to contribute significantly to a comprehensive environmental assessment.

The current state of the art is environmental science is such that different levels of precision are possible in different fields. There is considerable doubt that current knowledge is adequate to assess each element of a complex project at an appropriate level, or even to determine the level of precision required to forecast some elements of complex processes. Environmental science is still a relatively new field and it is concerned with a wide range of phenomena. While that suggests that caution should remain a byword for the foreseeable future, we believe that environmental forecasting can be improved. The role of feedback, such as can be provided by audits, is indispensable to such improvement.

CONCLUSIONS

The science and techniques that are vital to environmental management and to the conduct of EIA have progressed, but need to be improved. We suggest that:

- research should concentrate on re-establishing a more securely based environmental science, through clarification of
  - — ecosystem dynamics and paradigms,
  - — the nature and dynamics of cumulative impacts,
  - — the response of specific ecosystem components to different impacts;
- data for decision making and management should be more thoroughly and systematically gathered and carefully recorded — in particular,
  - — pre-project monitoring and operational and post-project effects monitoring should be designed in accordance with the concept of valued ecosystems,
  - — monitoring should begin as projects are being planned and should extend over an adequate period of time to allow for proper planning and management, — monitoring plans should aim at establishing statistically significant conclusions;

- mitigation measures should be undertaken and managed in a more systematic manner, in particular by
  - — keeping precise records of the institution of mitigation and the observed effects,
  - — evaluating and recording the effectiveness of particular measures,
  - — incorporating successful mitigation measures in engineering practice.

CHAPTER 4: PROCEDURAL AND ADMINISTRATIVE ISSUES ARISING FROM AUDITS

THE CHANGING PROFILE OF ENVIRONMENTAL ISSUES

Among concerned professionals in Canada, interest in the process of environmental assessment and its relation to the development planning process has increased. Environmental impacts continue to give rise to issues, although there are signs that they are somewhat less of a general political rallying point than the "environmental movement" made them a decade ago.

The reasons why environmental issues cause less controversy now include at least the following:

- issues are being settled in a more routine manner because they are better understood;
- standards which have been set are also better understood and therefore generally adhered to by all parties;
- uncertainty on several key issues has been reduced by research and experience;
- those who are "on the front lines" of the environmental debate of the last decade have now gotten to know and trust each other, if not perfectly, at least much better than before;
- other problems such as unemployment and a declining rate of economic growth are felt to be more important and are partly displacing environment as a major public issue.

Sequences of emerging awareness, followed by controversy and eventual acceptance of appropriate routine procedures have been experienced in respect of other public policy issues in the past. Is environmental assessment going the same route? Downs (1972), in his provocative discussion of the "issue attention cycle", argued more than a decade ago that that would be the fate of the ecology movement in the United States and for the moment time appears to have proved him right.

That such important and controversial issues as acid emissions and hazardous waste disposal are still outstanding makes it clear that environmental issues aren't all settled even if the approach to them is becoming calmer and more constructive. And the shadow of the past remains. Quinn (1985-i) noted that much of the public dissatisfaction voiced at the hearings of the Inquiry on Federal Water Policy arose from the environmental effects of past projects — evidence that something has been wrong with the project planning and implementation process. Because there is little to suggest that the process has changed, people appear to assume that the same problems persist. Despite the reduction in controversy, the project planning and implementation process is still suspect in the minds of some of the public and the cause of frustration to those directly involved.

Whatever the causes, Canadian concerns with the environmental implications of development seem to have shifted from an almost exclusive emphasis on specific environmental impacts to the more mature realm (as policy issues go) of management, of improving institutions, standardizing procedures and achieving efficiency and cost-effectiveness.

The Canadian case studies indicate that the best ways to manage environmental assessment are yet to be worked out. We still need to define the characteristics of structure and function most appropriate to reviewing and managing complex political, technical processes involving different interests and actors. The questions raised by the case studies relating to administration and procedure can be summarized as follows:

- How should EIA relate to broader and more fundamental planning processes?
- What are the most appropriate institutional arrangements, allocations of responsibility and procedures for EIA?
- How can the contributions to the public interest of competency groups be maximized?
- Can EIA be made more efficient?

Audits of EIA can help answer those questions and have already thrown some light on them.

EIA AND COMPREHENSIVE PLANNING

The role of environmental assessment in development planning has received continuing and intensive attention. Reviewing the environmental assessment of hydrocarbon production in the Beaufort Sea, Rees (1983) commented on EARP as follows: "As a mechanism that is external to the project and essentially reactive in mode, the present EARP is simply not an appropriate vehicle for project planning and design." Rees noted further that the EARP panel was precluded from considering the go/no go option: in the view of the initiating department the most critical decision, namely that development would proceed, had already been taken.

While EIA began as a discrete process associated with a particular project, the view that it should be an integral element of comprehensive planning is becoming more

common. O'Riordan and Sewell (1981) and their collaborators presented a major review of the topic, and in their introductory chapter the editors state their position clearly: "... we contend that EIA should be regarded as basically a symbol of a much more profound and exciting development in government, that of clarifying national priorities in all aspects of environmental management..." O'Riordan (1985) stressed the desirability of project assessment in the context of general planning, which includes the formulation of goals and objectives and is policy oriented. Along similar lines, Munro (1986) emphasized the importance of undertaking EIAs in a comprehensive policy context within a system of policy formulation, program planning and project design and implementation.

It remains our contention that environmental assessment should be an integral part of the planning process, and that it should be begun when project planning begins, not after fundamental decisions have been made and the opportunity remains only to modify the details of implementation. We may be moving in that direction. Boothroyd and Rees (1984) in a review of EIA over the past 10 years consider that "... the most important roles for EIA are increasingly seen to be in two directions relevant to public policy: first, in evening the odds — between proponents and impactees, between the larger society and the local community, and between society's immediate and long-term interests..." They suspect that activities now labelled as "EIA" may be "organically incorporated into both project design and community development planning." EIA as a discrete add-on activity, with only marginal impact on project implementation "will disappear".

Integration of environmental assessment with development planning at the project level calls for more satisfactory scheduling than has often been the case. Rosenberg *et al.* (1981) used the example of mineral development in the Canadian North to demonstrate that the lead time for proper environmental assessment was similar to that for exploration and deposit definition. They have argued that environmental assessment should begin at the same time as exploration so that development prospects can be explored with environmental management requirements as an integral part of the development issue.

The follow-up studies contain little with respect to this broad but fundamental point, and as yet there is clearly no concensus about the role of EIA in relation to major planning decisions. Ruggles (1985) states that the Wreck Cove Environmental Assessment was meant to maximize environmental benefits by incorporating appropriate mitigation measures into the hydro-electric project design, rather than assess whether the project was environmentally acceptable. Kiell *et al.* (1985), on the other hand, characterized the environmental impact statement as primarily a tool to decide whether a proposed project is acceptable, comparing it to engineering feasibility studies occurring in the conceptual phase of development.

Turning to the procedural characteristics of EIA that relate to planning, we find a tendency to follow either of two approaches. An administrative process pattern has been the more common. Orloff (1972), Matthews (1975), and Caldwell (1982) have provided expositions of this approach. An alternative is the organic planning perspective. It has been used by Hollick (1981) and Gianotti (1983), among others. The major characteristics of these two approaches can be summarized as follows.

Administrative Process Model

The administrative approach to environmental assessment has concentrated on ensuring that orderly, clearly defined steps are taken throughout the process. It may include a regulatory system in the legal and procedural sense, and it may go beyond that. It usually involves a set of rules (or a code) by which the need for an assessment can be determined and a set of guidelines about the type of assessment which is to be conducted. It often defines the questions which have to be answered. Some well established administrative processes have reached the point where they specify the levels of accuracy of the studies which are to be conducted. In short, the administrative process model relies upon procedural rules and the setting of standards.

The fundamental assumption of an administrative EIA process is that following all the right steps, as outlined in the rules, will result in the most environmentally acceptable project possible. That assumption is clearly open to challenge. The case studies related to the development of pipelines in Canada have shown that the rules are often imperfect. Following the rules results in a design which meets the rules without solving, or even identifying, problems which a less codified approach might turn up.

At the same time, an administrative approach tends to standardize the EIA process and the roles of the participants. The result is more order, less confusion. There may also be less flexibility and creativity in response to the unexpected. Criticism of changes in the direction of greater administrative efficiency acknowledges that the results are better than nothing most of the time. It also recognizes that codification often leads participants to "play by the book" rather than seek the best solution. In the United States adversarial system, particularly, some of the resulting solutions are clearly lower in quality than the codifiers had intended.

Organic Planning Model

An alternative approach which differs dramatically from the administrative approach is called "organic planning" or "integrated planning". Using that approach, there may never be an actual assessment of a project. Rather, sound environmental principles are built into project design from the beginning and at each stage of the plan. Environmental assessment becomes so integral to the design that a separate process would be redundant.

This approach works if environmental skills and perspectives are always represented on the design and development team. That may be achieved by having an applied environmental scientist as part of the planning group, or by having ecological education included in the training of planners (an even more integrated form).

This approach also has its weaknesses. The biases and knowledge limitations of the planning group will be reflected in

the plan. If the group is strong on hydrography, but weak on soil chemistry, that weakness is likely to be shown in the final design. Although the Wreck Cove project is perhaps not an example of organic planning, the conclusion of the Wreck Cove case study (Ruggles 1985) that the assessment of water quality did not make proper use of existing knowledge of water chemistry illustrates the point.

Another fundamental problem with the organic approach is that when it is followed, the need for an external assessment may seem less apparent and support for environmental assessments is reduced. Since the assessments are not done, there is little incentive to review the projects later; there is nothing to follow-up on. There may be a denial that an *ex-post-facto* evaluation has any purpose. The danger is that flaws in the planning process can go undetected, and evidence of their existence can be denied, for a long time. In fact, an audit of such a project threatens the planning process of the institutions since it is effectively an assessment of an integrated process. That threat is naturally resisted. However, there are techniques for disassembling the environmental components of such plans. In our view, audits are necessary in such situations and can be conducted successfully without necessarily taking on the entire planning system.

QUESTIONS OF RESPONSIBILITY, INSTITUTIONS AND PROCEDURE

As a consequence of law and custom, responsibility for environmental management in Canada is divided between and within governments and between the public and private sectors. Mandates and the ways in which they are discharged are well described in the comprehensive account by Couch (1982). It is not our intention to describe or analyse this situation and the actors involved in it in any detail. Suffice it to say that it would be difficult to change the division of responsibility, particularly that between governments, even if a change were deemed desirable. Since the environment is not divided in ways that parallel the constitutional division of responsibility we must ask what sorts of procedures and institutional arrangements will meet environmental needs while fitting into our governmental system.

FEARO and EARP, though relevant only to federally sponsored or funded projects, are very important not only because of the number and significance of such projects, particularly in the Territories, but also because FEARO may collaborate with and influence environmental institutions and procedures in the provinces. There are also frequent interactions between Environment Canada, exercising its responsibilities with respect to air, water, wildlife and national parks, the National Energy Board, the Department of Fisheries and Oceans (DFO), and provincial and territorial organizations responsible for EIA. There are further complexities in the Territories where the Department of Indian and Northern Affairs (DINA) and the line departments of territorial governments have very similar responsibilities.

The description of exercise of responsibility with respect to the Norman Wells pipeline (Jakimchuk *et al.* 1985) is illustrative of the complexities that result from jurisdictional fractionalization. A panel established under EARP (administered by FEARO) reported and made recommendations on mitigating action to the Minister of the Environment in January 1981. At about the same time, the National Energy Board (NEB) held hearings on the proponent's application for a Certificate of Public Convenience and Necessity. The NEB decision covered much of the same material as the EARP report and noted the terms and conditions under which the NEB would grant a certificate. In November 1981 the certificate was granted. A year later the proponent signed an agreement with DINA outlining responsibilities for studies, monitoring, mitigation and other activities. The agreement covered some of the issues identified by the EARP panel. The proponent also had to obtain water licences from the Northwest Territories Water Board. Federal agencies involved in regulating and monitoring construction and operation of the pipeline included NEB, DINA, DFO, Canada Oil and Gas Lands Administration, Department of Transport and Department of Environment; terrritorial agencies included the Department of Renewable Resources and the Department of Local Government. Jakimchuk states, "It is through the terms and conditions of the permits, licences and approvals controlled by these agencies that the EA panel's recommended mitigative and monitoring measures have been implemented, as EARP itself has no post-approval powers to ensure implementation." A comparable number of agencies from the federal and territorial governments was involved in the Shakwak project (Spencer 1985).

In the Coquihalla Valley corridor where pipelines and a highway have been constructed in recent years, two federal departments, Environment, and Fisheries and Oceans, and four provincial departments, Environment, Energy Mines and Petroleum Resources, Forests, and Transportation and Highways, have been involved in environmental assessment.

Several other case studies reflected similarly complex situations.

Two observations are prompted by the foregoing descriptions: the first is that it should be possible to devise a less complicated and, therefore, more cost-effective process for approval and monitoring of a project; the second is that it seems inappropriate that a body such as FEARO, which is primarily responsible for assessing a project and recommending mitigation and monitoring, has no power to ensure implementation.

A concern in the Territories and in several provinces was the duplication of effort needed to meet the requirements of several agencies. In some cases, proponents were faced with more than one agency hearing on the same issue. Pipelines are clearly important in this regard, since they involve the National Energy Board, sometimes FEARO and sometimes a provincial energy authority (as in Ontario), as well as the resource use (right of way) agencies and environmental agencies. The apparent redundancy has led to a certain cynicism and a great deal of frustration on the part of all concerned.

The sense of the case studies is that some inter-agency conflicts have been sorted out. There remains some confusion, however, about the role of environmental concerns and

agencies in those projects such as pipelines which are regulated primarily on some basis other than environment. One suggestion has been to restrict EARP hearings to issues not previously covered in the primary regulatory hearings (e.g., NEB Terms and Conditions). Under that condition, the material submitted as part of the primary review process would be presumed in any secondary environmental review. Thus, proponents and intervenors would not be in the frustrating position of resubmitting old material to a new agency.

Several of the case studies stated or implied the need for clear definition of responsibilities for all phases of EIA if unproductive institutional and interpersonal conflict is to be avoided. Moves in the direction of major institutional changes would not, however, be an obvious consequence of the case studies. The case studies suggest a clarification of existing roles, a confirmation of changes which have been occuring over the past 15 years and arrangements that would allow greater flexibility in sharing responsibilities.

Given the jurisdictional complexity of the Canadian scene, and of even more importance, the need to draw upon skills and intellectual contributions and to reflect biases from a range of different sources, special institutions must be established to design and manage procedures for undertaking EIAs and designing appropriate mitigation activities and monitoring processes. Panels or committee structures, often of at least two levels, representing proponents, regulators, scientists, clients and affected publics are the usual institutional response. An environmental co-ordinator may serve the committee or committees and help expedite the program. Referrals, consultations and meetings resulting in advice and decisions, are the usual regulatory procedures and products. There is great variation in the minutiae of structure and procedure, most often the result of the interplay of personalities and permanent institutions involved, but the general pattern is fairly constant.

The Shakwak Highway Project, which was submitted to the EARP for a panel review, is a useful example of EIA structure and process (Spencer 1985). The proponent, Public Works Canada, retained a consultant to prepare an environmental impact statement. The EARP panel convened hearings and eventually submitted recommendations with respect to project management, construction and mitigation. The project management recommendations were that a Shakwak Review Committee and an environmental co-ordinator be appointed. The Review Committee was to report annually to the federal Minister of the Environment and the Yukon Territorial Council. It was composed of representatives of the Yukon Territorial Government, EPS and DINA. Its functions were to review and report on the implementation of the panel's recommendations and the proponent's commitments, to evaluate further studies and mitigation measures and to ensure that channels of communication among groups interested in the project worked. The co-ordinator was to make field checks of construction, instruct project management and contractor's staff and report to the Review Committee. He also reported to the Project Manager who translated the co-ordinator's findings into action at the project site. For two years the co-ordinator's position was filled full time; subsequently it became the part-time responsibility of a person not otherwise connected with the project and based in Vancouver. Another body, the Shakwak Environmental Steering Committee, was formed to co-ordinate action needed to meet regulatory requirements. It included representatives of nine subdepartmental agencies of the federal and Yukon governments. The Review Committee strived to facilitate high-level communication between interested departments. It was not successful in having environmentally based guidelines for the project completed or having a social impact assessment undertaken. The Environmental Steering Committee streamlined and standardized permit procedures but did not have inadequate terms and conditions upgraded. The environmental co-ordinator operated effectively as an integral part of the project management teams during the first two years of the project. Less frequent monitoring after the position became a part-time one had some adverse effects.

The Banff Highway twinning project was co-ordinated first through a simple steering committee and later through a more elaborate committee structure representing three federal agencies, Public Works (the builder), Parks Canada (the land owner and "client"), and Environment Canada. The committee structure, a policy committee, a decision-making senior committee and four subcommittees — design, environment, construction and public relations — had been recommended by an EARP panel which also called for the preparation of an EIS and convened public hearings. An environmental co-ordinator, formerly an employee of the Park Warden Service, was appointed by Public Works to report to the project manager, meet with the subcommittees and maintain a day to day relationship with on-site supervisors. According to the follow-up report (Janes and Ross 1985) the operating style of the committee structure, the co-ordinator and the project manager, was highly interactive and generally effective. It was able to respond effectively to unplanned events. The overlap in reporting arrangements for the co-ordinator was at times a sensitive matter and there were occasional clashes. Acceleration of the project without adding qualified environmental personnel to project staff created undue stress.

Besides a committed structure established for the life of a project, there may also be set up joint industry/government/university working groups to resolve difficult technical or scientific issues. Such was the case, for example, for drilling mud disposal on the east coast (Everitt and Sonntag 1985).

Several case studies reported difficulty in determining co-ordinating arrangements, procedures followed, etc. through the course of projects because full records were not available.

The case studies suggest several recommendations relevant to administrative structure and procedures:

- clear definition of the division of responsibilities among co-operating agencies will minimize confusion and consequent delays and mistakes;

- continuity of membership in committees and of responsibility for co-ordination is highly desirable;

- reports are important as a record of what is done and learned; they should be submitted as scheduled; relevant information about experience at other sites should be sought out and utilized.

Analysis and discussion of the several committee structures established for project management has not answered all the questions that might be asked. Can we develop guidelines for determining which players in a project (proponent, protector, public user, construction manager, etc.) are best suited to the various roles on the project management structure (policy committee head, public interaction, design control, etc.)? An important question is whether some structures work primarily because of the efforts of one or several particularly dedicated and skillful individuals?

HUMAN AND ORGANIZATIONAL RELATIONS IN THE ASSESSMENT PROCESS

From the case studies of the Beaufort Sea exploration and Ontario pipeline projects, a common message emerged about the significance of human relations in the assessment process. Initial hearings were marked by a sense of suspicion, of confrontation among different organizational interests. Developers and regulators experienced mutual distrust. There were also conflicts among government organizations. In Ontario, they were often between federal and provincial agencies. In the Territories, the conflicts were between federal agencies, a reflection perhaps of lesser local authority there.

Over time, both the human and organizational relationships have smoothed out considerably. With experience, jurisdictional confusion has been reduced. The Ontario government, for example, now appears to have a much clearer understanding of the areas in which it has sufficient jurisdiction to be effective: during the early pipeline monitoring programs, much effort was wasted on matters over which the federal government was held to have jurisdiction. In addition, the case study relating to the activities of Union Gas suggests that the maturity of an organization in terms of its experience with EIA, the quality of its contractors, and its acceptance of the value of environmental quality may influence the trade-offs between proponent, regulator, and public advocate. In the case of an experienced organization with a proven record of good environmental management, less needs to be done by the regulator and public. When an inexperienced organization is involved, a heavy burden may fall on those other then the non-proponent.

An interesting finding from several of the case studies is that important changes occurred in the interactions of individuals representing different organizational interests. Representatives at first assumed that their primary responsibility was to defend the interests of their own organization in the face of similarly aggressive efforts by others. Over time, those attitudes modified. Several years of contact between industry and government officials at the working level led to the establishment of greater understanding. The interaction not only put "a human face" on the representatives of other organizations, it also helped create an understanding of the technical assumptions, limits, and credibility of the various parties.

As a result, members of long-standing working groups, or persons who have come together a number of times to discuss different issues have established an easier rapport than was the case when they first met. Industry representatives have a better understanding of public officials' requirements and the officials have a better sense of industry's capabilities and motivations. In fact, in one case the introduction of a new player to an established circle of this sort lead to noticeable pertubations as the "new boy" was brought into the circle of understanding established over the course of a couple of years.

There are clear implications in such findings for both government and industry organizations: stability is hard-earned and easily upset by new appointments insensitive to an elaborate technical culture.

While this socialization process was uncovered in several of the case studies, there was concern expressed over its implications for organizational interests. Does the rapport develop at the expense of dangerously compromising the interests each person is there to represent? To what extent is compromise in the interest of resolving issues beneficial or harmful to society and to the participating organizations? How do new interests, arising as a result of social, economic, political, or scientific changes, enter the circle? Those are some of the questions provoked by the findings and they are worthy of considerably more attention and research.

The University of British Columbia's Westwater project has dealt with ways to handle situations dominated by difficult issues and where differing interests are at stake by developing a bargaining technique for planning and development. Bargaining is held out as both a useful means of understanding the myriad adjustments which occur in project design — and as a positive model through which the adjustments can be made more smoothly. For a clear exposition of the model in action, see Dorcey and Martin (1985a).

The complicated nature of environmental problems and the pressure to find solutions clearly pose difficulties for participants in EIAs. Disaggregation of complex and controversial issues may be helpful. By this means the scope and complexity of issues may be reduced to levels that enable participants in technical working groups to resolve them more readily.

But a smoothly working process to reassemble the components of the project after it has been disaggregated has not yet been worked out. Of even more importance, once the group-level problems have been resolved, there does not appear to be a systematic technique to solve higher order problems. Additional mechanisms may be needed at the policy level and perhaps the bargaining technique should be more widely applied. The working group model suggested that representatives on a working group can establish a co-operative attitude among their policy-level superiors, essentially by setting the stage with working level co-operation and problem-solving success.

The case study of the Utah and Amax mines (Dorcey and Martin 1985b, 1985c) particularly, led the investigators to

focus on the importance of personal skills in resolving environmental management issues. They concluded that specific attention to the development of interpersonal and group skills should be included in post-secondary education and organizational development programs. They also concluded that further attention should be given to the evaluation of innovations aimed at reaching agreement in the resolution of difficult issues.

In respect of public involvement, the sense of the case studies, was that if it was arranged at an early stage of the project, it would have a twofold benefit. On the one hand it would ensure that the information and opinion contributed by the public could be usefully incorporated in the decisions, and on the other hand, the earlier that information was given to the public and the earlier the public had a chance to react to it, the greater the possibility that friction and confrontation could be minimized and time saved.

Jakimchuk *et al.* (1985) found that the manner in which the public perceives an impact affects the speed with which an issue can be resolved. If both the public and technicians consider an issue important, there will be more effort to resolve the issue in a positive manner. Thus, the process of assessment, EARP in particular, can serve as a forum where both political and technical issues can be explained and resolved. But the usefulness of this exchange will be limited if it refers only to the preconstruction phase.

Moncrieff *et al.* (1985) found that, "... an earlier involvement of the public in the environmental planning and approval process... reduced costly delays". On the other hand, Jakimchuk *et al.* (1985) noted the feeling of some observers that EARP preoccupation with public participation can lead to public reviews that are unnecessarily long. Thus, the time and manner of involvement of the public is crucial to ensuring a smooth participative process.

The question of how the public can contribute is also important. In many cases, it was found that if the information was presented to the public in a very technical manner, the ability to understand, comment and contribute to the decision process was limited (Dorcey and Martin 1985b).

In spite of these difficulties, there is evidence "that following a logical comprehensive and open procedure" in which the public can participate, will produce more "satisfactory results" overall (Moncrieff *et al.* 1985).

QUESTIONS OF EFFECTIVENESS

It is clear that there has been little systematic analysis of the effectiveness of environmental assessment in the overall management of resource development projects. In some instances, that has been a result of the short time since the assessment. In most, however, it has been caused by a lack of institutional continuity to support a sustained monitoring and evaluation process. In addition, there is a widespread presumption on the part of development agencies that their responsibility has been met by undertaking the assessment and any mitigative measures subsequently required.

An exception to the lack of follow-up is recorded in the American literature of the mid-1970s which reviewed the implementation of the NEPA of 1969. Reports such as Council on Environmental Quality (1976) and Anon. (1973) outlined the difficulties and opportunities presented by the American regulated assessment process. From interviews and correspondence conducted as part of this review, it appears that the content of the American follow-ups was quite different from what is now being attempted in Canada. The U.S. effort has been directed almost exclusively to establishing "due process" structures. Environmental assessment is to take place at a specified time in the development process, and certain impacts are to be delineated. Clearly defined administrative responsibility and the threat of litigation have been employed to ensure that the accepted procedure is followed.

What does not seem to have taken place in the United States is a follow-up of the actual content or results of the processes that have been established. It is not known, for example, whether changes in procedures have resulted in lessening the types of impacts actually experienced in various ecosystems. It is startling to realize that the tremendous outpouring of emotion on environmental issues in the United States in the 1970s has been effectively blocked by procedural changes and by providing for more open participation — but without any proof that environmental management has improved.

The best tests of the effectiveness of EIAs would undoubtedly be provided by monitoring in accordance with a plan designed to establish the relationship between what is predicted and what actually occurs. The realization that that seemingly simple process is fraught with difficulties has led to the notion of tracing the history of environmental issues (Everitt and Sonntag 1985). This is more than a surrogate for a rigorous prediction and scientific reassessment; indeed, if the conditions of most projects were such that a scientific reassessment was feasible and effective, it would still be desirable to track the issues since that process is more useful in evaluating the effectiveness of institutions and procedures.

A number of the conclusions derived from tracking the issues associated with selected frontier oil and gas projects have already been noted; but perhaps the most fundamental one remains — that environmental assessment is an ongoing process, within which issues are continually being raised and resolved, perhaps later to re-emerge as a consequence of new information heightened awareness or unexpected events (Everitt and Sonntag 1985).

Related to the idea of tracking issues is the concept of issue management. There is a practically infinite number of situations which could turn into "issues" needing attention on most large development projects. Insofar as environmental implications are concerned, what leads some to become politicized while most never reach that stage? Can environmental assessment be used to minimize controversy while maximizing environmental protection and the sustainability of resource use? Some of the case studies have touched on this subject, but it does not seem to have been the focus of any of them.

Issue management is a concept which, although derived from EIA, goes beyond it in using the opportunities presented by

assessment to minimize both adverse environmental effects and unproductive controversy. The aspect of issue management that has received most attention in the case studies is the use of issue containment strategies, primarily by project proponents. The following positive strategies with respect to environmental issues were identified:

- aggressively seeking to put the best possible environmental solutions into proposals, thereby ensuring that the regulatory bodies would have nothing to challenge (this involved going beyond regulatory standards in many respects),
- conducting research, monitoring, and community information programs in advance to ensure that the potential issue was always seen to be an immediate concern of the proponent, thereby preventing allegations of inattention and failure to recognize impacts,
- quick and immediate response to issues raised by other parties, whether regulatory or community, and
- responses designed to assert the fact of compliance with regulatory standards.

Examples of each mode were recorded in the case studies. One study found three of the four among different companies operating in the same regulatory environment at the same time (Cosburn and Torrens 1985-i).

It is worth noting that the two most positive examples of the first strategy identified above involved companies which either wanted to establish an image which would make them the leading contenders for expected follow-up work ,or were widely owned within their area of operations. In the latter case, shareholders, clients, and neighbours were familiar with each other and had overlapping roles to a considerable extent. Both considerations seem to favour "good corporate citizenship" in respect to environmental aspects of the planning process.

Information on the costs of environmental impact assessment, mitigation and monitoring, like information on the cost of environmental management generally, is hard to come by. Only five of the case studies referred to EIA costs and only one, the study of the Newfoundland hydro-electric projects (Kiell *et al.* 1985) dealt with cost data in detail. Kiell *et al.* noted that it is the private sector that bears most of the costs. The reasons that costs are not well known are that the data may be considered confidential, record keeping may not differentiate environmental from other costs and, in any case, the proponents may not be interested in publication. Moncrieff *et al.* (1985) also stated that data on costs were generally not available, as much as anything because they were relatively low and also because most were not differentiated from planning or routine construction costs. Costs associated with relocating pipelines to avoid areas of particular environmental interest could, however, be considerable.

The total value of "environmental contracts" associated with the Banff Highway project was 16.4% of total project expenditures (Janes and Ross 1985), but some of the costs of landscaping should probably be considered as routine and the percentage given should therefore be taken as a high estimate. The cost of vehicle repairs necessitated by collisions with wildlife was noted to be almost $100,000. per year. It was suggested that if that were capitalized, the expenditure of $1.6 million on underpasses and fencing would appear to be very worthwhile.

Dorcey and Martin (1985b) thought that the Utah and Amax mines might frequently have spent between half a million and a million dollars a year on monitoring and assessment. They recommended that funding should be a subject for negotiation and agreement early in a project.

The Newfoundland study includes a detailed and interesting analysis of environmental costs. The cost of environmental protection incurred by the developer during assessment, construction and operation averaged eight to nine million dollars for the three projects. All components of environmental costs increased over time because of increased expectations from government and the public. Costs of assessment ranged from 0.22% to 0.23% of total project costs, or from 41.2% to 49.4% of engineering planning costs. Costs during construction varied from 1.0% to 4.4% of total project costs, the largest elements being for reservoir clearing. Costs during the operational phase were relatively small except for those of water release, which were close to those for the construction period. Administrative costs ranged from 5% to 15% of the overall costs of environmental protection and increased as successive projects were undertaken. Kiell *et al.* (1985) concluded that the cost of an environmental monitor was small compared to the benefit of having one on site.

Substantial investments are being made in environmental impact assessment and the need to evaluate those assessments is the major theme of this paper. It will not be possible to do this properly unless more extensive and accurate data on costs are obtained.

CONCLUSIONS

The general sense of the case studies is that the process of EIA has lessened the impacts of development and reduced the controversy aroused by environmental issues. But there is also much dissatisfaction about the management of EIAs and a belief that the process can be greatly improved. We believe that improvements would flow from

- a closer integration of environmental impact assessment with development planning,
- clear definition and continuity throughout a project of responsibility, and elimination or reduction of overlapping responsibilities,
- simplification of administrative procedures,
- placing greater emphasis on the development of skills in dealing with interpersonal and group relationship,
- installation of a better system of defining and accounting for environmental costs.

CHAPTER 5: POLICY IMPLICATIONS

THE ROLE OF POLICY

Concerns about existing systems of environmental impact assessment and the role of assessment in environmental management arise from limitations in knowledge and, probably of more importance, in organization. The problems of current Canadian practice relate to the role of environmental assessment in the planning process, its predictive capacity, and the congruence between its purpose and its execution. These concerns must be met before environmental assessment can achieve its potential as a strong tool of modern environmental management. It is at the level of policy that most of these issues can be addressed effectively, by providing the guidance and climate for change and improvement.

The audits examined in this project indicate that some means of alleviating these concerns are well developed while others will require creativity, additional research and perhaps some boldness in formulating and applying innovative policy. In this chapter, major problems with the existing system are summarized, and recommendations for resolving them presented.

PROMOTE ENVIRONMENTAL SCIENCE

A major rationale for the present studies has been a concern about the scientific quality of the hypotheses and data upon which environmental assessments are based. While the ultimate bases for policy making are the ideological positions of society or of groups within it and the assumptions and implications that flow from them, the policy maker wishes to use scientific knowledge to make his decisions practicable, efficient and credible. If assessments are to be used in the policy-making process, their quality needs to be understood. What levels of confidence should be attributed to their predictions?

The results of scientific investigations may be phrased in terms that are either more or less exact than policy or operational needs require. In the case of broad policy decisions where considerations of economic and social values are weighed in association with environmental values, there is no compelling need to strive for a high degree of scientific accuracy since in its degree of certainty the decision will, in any event, reflect only the level of accuracy of its least quantifiable components, namely the social and economic values. There is, on the other hand, a good deal to be said for attempting to render more precisely those forecasts that may influence decisions on scale and design of structures, for example, or the operating regime of a dam. Such decisions are expressed in terms that are precisely measurable and may usefully be related to comparably precise statements or predictions of environmental parameters.

Scientific accuracy is a difficult concept to operationalize. Within any particular scientific community, accuracy tends to be a product of the maturity of the discipline, the nature of the currently dominant paradigm (Kuhn 1970) and the sophistication of existing measurement tools. It is hard to see any relationship between the concern for accuracy within any discipline at a particular stage in its development and the level of accuracy required for policy making or environmental management decisions. In a policy-making setting, the level of accuracy needed depends on the nature of the issue to which the scientific evidence is to be turned.

The discrepancy between the levels of accuracy that science achieves or strives for and the requirements for accuracy of scientific contributions to policy poses problems. When a science is mature and its practical applications well established, it can provide a reliable and credible backup for policy decisions. This is largely the case with what we call the exact sciences — physics and chemistry. When a science is less mature and its practical applications are imperfectly understood, it is unable to provide the basis for firm policy decisions nor can it readily lend them credibility. This is the case with the social and to some extent the biological sciences — sociology, economics and the various branches of ecology.

The practising scientists whose role is to provide scientific information for policy makers tend to take one of several stances: they may be reluctant to draw back from the refinement of their professional debates to provide data that are intelligible to the (lay) decision maker; they may be unable to present data in a usable form; or, hopefully, they may be able and prepared to present exact, coherent data in a form usable by decision makers.

In the case of mature science, the scientific input for decision making is largely unequivocal, and the uncertainty of eventual results is a result of the uncertainty of social choice. In the case of the newer sciences, the scientific input is ambiguous and imprecise, with the result that the entire decision process is based on uncertainty.

Ecologists appear to find themselves in this last situation and environmental management remains imperfect. For example, important issues about the long-term effects of dilute quantities of highly toxic trace elements are in the policy arena now, but the relevant scientific knowledge will take many years to accumulate to the level which scientists feel is an acceptable basis for important social decisions. Although scientific uncertainties remain, the public interest must be served as best it can be, and policy makers must act.

The predictive capacity of environmental science will improve only with practice and with adequate provision for information feedback. While EIAs, monitoring and EIA audits are undertaken for operational purposes, they can contribute greatly to the progress of science if they are utilized as a vehicle for relevant research. Every opportunity should be taken to do so.

Seizing such opportunities for research is not enough if environmental science is to serve economic development and human health and welfare satisfactorily. Governments particularly, but universities and industry as well, should recognize that environmental research must be maintained and expanded in accordance with a carefully designed set of priorities. They should adopt research policies which reflect the fact that many ecological processes unfold over decades and that the impact of some environmental perturbations may only be revealed at a similar pace.

INTEGRATE ENVIRONMENTAL ASSESSMENT WITH DEVELOPMENT PLANNING

The decision-making process is shaped by the structure of governmental machineries and the requirements of relevant laws and regulations. As noted earlier, we do not believe that the present structures and requirements support a sufficiently integrated approach to development planning, although there is evidence of movement in that direction.

The financial and administrative arrangements that would be required to undertake environmental assessments of activities that cut across areas of jurisdiction and that span more extended periods are not clear. What is clear is that, instead of being tied to the regulatory response-to-proposal process, EIA should be linked to the development strategy and planning process. A careful analysis of the functional characteristics of EA systems now in place, followed by the formulation of recommendations for a more integrated process would be necessary to provide the basis for what could be a substantial institutional shift in most Canadian jurisdictions.

Environmental concerns should be on the same footing in long-range planning as other aspects of development, such as social impacts, economic effects, market requirements, financing and construction technology. All such factors need to be taken into account in the decision-making process.

To ensure that this comes to be so, environmental requirements should be embodied in social goals and reflected in development plans (Munro and Matte-Baker 1984). If, as in Canada, social goals are rarely explicit and comprehensive planning systems are lacking, other means must be used to influence the direction of development. These include legislation, conservation strategies, ministerial policies, development guidelines, regional land use plans, etc.

Whatever means are chosen, it should be recognized that there are three levels at which environmental impacts may be felt and should be assessed. It is important to understand how impacts at the three levels may interact and how such interactions should be assessed and taken into account in management. In assessing the environmental impact of actions at any one level it is necessary to consider interactions with activities, many of them cumulative, at the other levels.

One level is sectoral or regional, e.g., agriculture, forestry or a watershed. Sectoral activities are not often subject to EIA and land use plans that have been prepared are not always the main bases for management. Nevertheless, the preparation of regional and sectoral plans in which environmental considerations are taken into account can provide a comprehensive context within which specific projects may be more meaningfully and easily assessed.

The second level is the project, on which EIAs seem to have been focused almost exclusively. Where sectoral or regional plans are the basis for management, the preparation of a project EIA should be a much simpler task than elsewhere and decisions on projects should be less subject to controversy.

The third level is that of the numerous, dispersed, discrete actions that have an impact on the environment. Applying pesticides in backyards, or operating vehicles are examples. These actions individually have small impacts, but the sum of their impacts may be large and significant. To the extent that these actions are regulated, it is by product standards, guidelines for use, etc., because an overall assessment would be difficult and comprehensive control virtually impossible. The problem with that strategy of management is that it takes no account of the cumulative effect of many actions. There may be a need to work out an assessment procedure that will yield a better measurement of the impact of such interventions.

Canadian jurisdiction should consider putting in place a comprehensive environmental assessment process closely integrated with whatever process is used to guide and plan development and taking account of activities at all levels.

PROVIDE A BETTER INFORMATION BASE

Information is the basis for enlightened decisions, but the information about the environment upon which development plans and decisions should be based is widely dispersed and relatively inaccessible.

Many EIA reports may be found only on the shelves of the proponent, the consultant and the regulatory agency. Most often they fail to become known to other developers, other environmental consultants or the regulatory authorities in other jurisdictions. They are rarely published and thus infrequently studied or referenced. Valuable information and conclusions remain out of reach of those who might use them to improve their performance. As a consequence, we keep reinventing the wheel.

Steps should be taken to ensure that all information relevant to environmental management is made more accessible through a central catalogue and referral system. This might be done through strengthening existing institutions, which already have the capability, such as the National Research Council library. Relevant material would include data on the state of the environment, baseline studies, land capability maps, etc., as well as environmental impact statements, records of proven mitigation measures and reports on audits and evaluations.

The literature and the case studies reveal concern that EIAs are started too late and ended too early. They yield too little, if any, of the time-series information needed to establish patterns of variability in the environmental parameters. Timely gathering of information — pre-project, operational and effects monitoring — is required as the basis for design, mitigation, audit and evaluation of projects.

Monitoring needs to be begun well in advance of project implementation to establish a credible baseline against which to assess impacts. Just how long the lead-time for monitoring should be will depend upon the nature of the relevant environmental variables; but it seems unlikely that it should be less than one year. In many cases, however, monitoring starts at the beginning of or during construction. Often, too, monitoring does not relate to all the factors of significance to environmental change; consequently, observations made later have no reference to baseline conditions.

Construction tasks are often seen as the critical part of development. Planners and contractors focus on "getting it built". From an environmental standpoint, however, monitoring and mitigation should usually continue after the commissioning ceremonies. When the builders move on to their next project, who will do the monitoring? And where will the incentive for mitigation and compliance come from? Who will propose and support long-term adjustments in mitigation procedures? If we cannot respond positively to those questions, how can we evaluate mitigation? Such concerns are not always reflected in the design and construction process. More force should be put into monitoring requirements, making satisfactory monitoring processes and results a requirement for continued approval. Putting the burden of proof of compliance on the operator is important in this respect.

Information acquired during the course of similar projects could be useful. We found no case of a regulatory authority requiring such information as evidence. Use of such information would facilitate the exercise of hindsight, making it easier to improve designs for new projects. It would also help in increasing the accuracy of environmental forecasting. A third benefit might be an improvement in the quality of monitoring and mitigation out of concern for the attention a project might attract at a later date when it could be used as an example for another project.

Attention should be given, perhaps by CEARC, to ensuring the publication of valuable reports and to the best means of establishing a clearing house for information on EIA. Canadian jurisdictions should formulate and implement policies to ensure that environmental assessment and monitoring take place over periods sufficient to ensure that environmental parameters are properly defined and impacts effectively measured.

PRESENT INFORMATION EFFECTIVELY

Some EIA reports are overly bulky and almost impenetrable because a tendency has developed to measure and report on everything until time or money runs out. This is usually because no consensus has been reached on the critical issues to be examined. The resulting documentation is rarely read and hardly ever digested by decision makers at any level. In such cases the EIA has little value in the decision process. In the United States, this phenomenon has come to be called the "Niobara effect" after a Bureau of Land Management review showed that a massive environmental impact statement (EIS) on the development plans for the Niobara River was ignored because it was simply beyond the scale of interest of decision makers (Clawson 1985-i). The U.S. Commission on Federal Paperwork (1977) identified EISs as a significant problem in the U.S. government bureaucracy, largely due to their voluminous documentation.

A second reason for unwieldy assessment documents is poor writing, exacerbated by vague or nonexistent guidelines on the forms in which the assessments are to be presented to various audiences.

Proponents and review agencies should adopt policies and promulgate guidelines that will result in the presentation of succinct and readable EIAs.

SIMPLIFY RESPONSIBILITIES, IMPROVE ADMINISTRATIVE PROCEDURES

The diffusion of responsibility for environmental management between and within governments is certainly the cause of much of the complexity that frustrates proponents, consultants and the public. While we must clearly continue to live with some institutional fragmentation, it may be possible to reduce the present burden, at least that which arises within governments if not between them.

One possibility would be to develop a different type of regulatory agency, one designed to serve more as a expediter or clearing house for development issues, including environmental aspects. Such an agency would be closer to the intended role of the Canadian Economic Development Co-ordinators than to the regulatory role of, for example, the U.S. Environmental Protection Agency. It would serve as a relatively neutral project manager, disaggregating projects into components which could be dealt with by various means, including reaching technical consensus, doing additional research, drafting legal opinions and political bargaining. Its role would be that of an expediter doing everything necessary to clear away obstacles to decisions. Such an institution might also be charged with managing the regulatory process by determining which aspects of a project proposal should be submitted to which regulators, and informing other interested parties so that they might participate. The mandate of such a super-agency would have to allow it to do its job exceedingly well so that it could do a better job. It could usefully be an integral part of whatever organ of government is most concerned with economic planning and development.

If, as a first step, responsibilities are simplified or the actions taken to meet them better co-ordinated, simplification of administrative procedures should be relatively easy to specify and implement.

A more detailed analysis of the options for simplifying responsibilities for environmental assessment within the Canadian system should be undertaken by CEARC. The matter might later be considered by the Canadian Council of Resource and Environment Ministers.

IMPROVE RELATIONSHIPS

Canadian experience suggests that participants in EIA readily recognize the roles of different organizations, groups and experts in the assessment process and seek to minimize, not always successfully, the rigidities of regulatory processes. There seems to be an eagerness to improve.

The case studies suggest that the elements of an adequate working process that can be applied throughout the stages of assessment, mitigation, and monitoring (the last to a lesser extent) seem to be evolving. These elements consist of the following problem-solving steps:

- statement of basic assumptions with regard to objectives and scope,
- reduction of issues to specific technical questions, where possible,
- establishment of all-party technical working groups to address specific questions of engineering, finance, ecology, etc.,
- provision of sufficient time for members of the working groups to get to know each other well enough to establish a basis of mutual confidence and trust,
- acceptance of the primary objective of finding solutions acceptable to all parties rather than dedication to the cause of the participant's home organization.

These practical techniques for solving problems and reaching agreement should be the subject of courses for training persons involved in EIA and should be promoted by governments and organizations having responsibilities for EIA.

At another level, the importance of involving the public in EIA is generally accepted, but there is concern that current methods of doing this are not satisfactory. Public hearings, as they are presently conducted, tend to promote confrontation rather than co-operation. The marked technical tone of the hearings often makes it difficult for the public to understand and therefore contribute to the decisions. The costs and delays of this process are not inconsiderable. Finally, public involvement often takes place after major decisions have been made, and there is therefore little scope for further contribution.

Consideration should be given to instituting a more routine, less elaborate and costly type of consultation, at each stage of assessment, with exchange of information and views between technicians and the public, adjusting positions in a dynamic manner.

IMPROVE COST-EFFECTIVENESS

Governments and corporations all have a responsibility to citizens and shareholders to do what they need to do at the least possible cost. A number of the suggestions for policy shifts made in the preceding paragraphs would, if adopted, improve the cost-effectiveness of EIA. These include:

- making use of existing information and drawing upon experience,
- better scoping — to reduce unnecessary assessment and monitoring,
- eliminating overlapping responsibilities and consequent duplication of activities,
- adopting a best — practicable — science approach in operations as opposed to research.

If full advantage is to be taken of those suggestions, a more careful analysis of the possibilities nationally and in each jurisdiction is required.

A step of major significance in increasing cost-effectiveness, that could be taken now, would be to improve communications and promote the dissemination of timely, well presented information to those concerned with environmental impact assessment.

AUDIT AND EVALUATE MORE PROJECTS

We believe that the results of audits and evaluations will be useful in improving EIAs and environmental management as a whole. So far, too little has been done. The usefulness of audits would be much improved if the body of information revealed by audits were larger.

In future, audits should be undertaken as a regular aspect of the long-term management of all development projects. This would be made easier if guidelines for EIAs included directions to conduct them so that they could readily be audited later.

It is also desirable to begin a more concerted approach to auditing or evaluating projects already completed and ensuring feedback of the resulting information to regulatory agencies as an input to improving regulations, and to proponents for the improvement of project design and execution.

Consideration should be given to the adoption of responsibility for fostering and facilitating audits by existing governmental institutions. This need not be a costly or demanding undertaking. FEARO is obviously a possible seat for such a function in the federal government, but the possibility should be explored that it might be undertaken by the office of the Auditor-General so that environmental auditing would be an integral element of the audit of development projects and programs. Possibilities for assuming the same responsibility in each province should also be investigated. Another possibility is that governments might jointly mandate the Canadian Council of Resource and Environment Ministers to take on the task.

Whatever mechanism were adopted it could be looked upon as experimental and subject to review after, say five years.

Our society relies upon efficient use of financial and human resources as a vital test of economic activity. Audit and evaluation with reference to predetermined plans and budgets have proven to be essential in ensuring the efficiency of both private and public enterprises. Our environmental resources, upon which our survival totally depends, must also be used with care and wisdom. Environmental impact assessment has been accepted as a necessary element of development planning. Audit and evaluation of environmental impact and the use of environmental resources must become as much a matter of routine as the comparable processes are in business.

BIBLIOGRAPHY

Ackermann, W.C., G.F. White, and E.B. Worthington (eds.) 1973. *Man-Made Lakes: Their Problems and Environmental Effects*. American Geophysical Union, Washington, D.C.

Addo-Ashong, F.W. 1969. The effects of flooding on decomposition of wood. In *Man-Made Lakes* (L.E. Obeng, ed.) Accra: University of Ghana Press.

Andrews, Richard N.L. 1976. *Environmental Policy and Administrative Change: Implementation of the National Environmental Policy Act*. Lexington, Mass.: Lexington Books.

Andrews, Richard N.L., and Mary Jo Waits. 1978. *Environmental Values in Public Decisions: A Research Agenda*. School of Natural Resources, University of Michigan, Ann Arbor.

Anon. 1973. *How Effective are Environmental Impact Statements*? National Technical Information Service (NTIS) Special Report PB-230 702 (July).

Ascher, William. 1978. *Forecasting: An Appraisal for Policy-Makers and Planners*. Baltimore: Johns Hopkins University Press.

Asian Development Bank. 1985. Synopsis of ADB Annual Report. *ADB Quarterly Review*, April, 1985.

Atton, F.M. 1975. Impact analysis: hindsight and foresight in Saskatchewan. *Journal of the Fisheries Research Board of Canada* 32:101-105.

Balasse, B. 1976. *The "Effects Method" of Project Evaluation*. World Bank Staff Working Paper 231, World Bank, Washington, D.C.

Balinsky, B.I., and G.V. James. 1960. Explosive reproduction of organisms in the Kariba Lake. *South African Journal of Science* 56:101-104.

Ball, J. *et al.* 1975. *Effects of Original Vegetation on Reservoir Water Quality*. Technical Report No. 64. Texas Water Resources Institute, Texas A&M University.

Ballo, Ivan Z., and Istvan Orloci. 1975. Water resources development in the Tisza River basin and its impact on socio-economic growth. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Bankes, Nigel, and Andrew R. Thompson. 1980. *Monitoring for Impact Assessment and Management: An Analysis of the Legal and Administrative Framework*. Westwater Research Centre, University of British Columbia, Vancouver.

Bardach, Eugene, and Lucian Pugliaresi. 1977. The environmental impact statement vs. the real world. *The Public Interest* 49 (Fall):22-38.

Barnthouse, L.W., J. Boreman, S.W. Christensen, C.P. Goodyear, W. Van Winkle, and D.S. Vaughan. 1984. Population biology in the courtroom: the Hudson River controversy. *BioScience* 34:14-19.

Bartlett, Robert V. 1980. *The Reserve Mining Controversy: Science, Technology, and Environmental Quality* . Bloomington: Indiana University Press.

Baxter, R.M. 1977. Environmental effects of dams and impoundments. *Annual Review of Ecological Systems* 8:255-283.

Baxter R.M., D.A. Bondy, P. Glaude, and D.W. Phillips. 1975. *The Prediction and Control of Environmental Effects of Dams and Impoundments in Canada: A Review of the State of the Art*. Canada Centre for Inland Waters, Burlington, Ontario.

Baxter, R.M., and P. Glaude. 1980. *Environmental Effects of Dams and Impoundments in Canada: Experience and Prospects*. Canadian Bulletin of Fisheries and Aquatic Sciences No. 205. Department of Fisheries and Oceans, Ottawa.

Beanlands, G.E., and P.N. Duinker. 1983. *An Ecological Framework for Environmental Impact Assessment in Canada*. Institute for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia; and Federal Environmental Assessment Review Office, Hull, Québec.

Bendix, Selina, and Herbert R. Graham (eds.) 1978. *Environmental Assessment: Approaching Maturity*. Ann Arbor, Mich.: Ann Arbor Science.

Benedict, J., and C. Wasserman. 1972. *The Brandywine: Five years after*. Institute for Environmental Studies, University of Pennsylvania, Philadelphia.

Berkes, F. 1981. Some environmental and social impacts of the James Bay hydro-electric project, Canada. *Journal of Environmental Management* 12:157-172.

Berkes, F. 1982. Preliminary impacts of the James Bay hydroelectric project, Quebec, on estuarine fish and fisheries. *Arctic* 35:524-530.

Berkes, F. *(in press) Environmental impacts of major hydro developments in Quebec: the James Bay project*. Bulletin of the Canadian Society of Environmental Biologists.

Bisset, Ronald. 1980. Problems and issues in the implementation of EIA audits. *Environmental Impact Assessment Review* 1(4)(Dec.):379-395.

Bisset, Ronald. 1982. Environmental Impact Assessment: The Role of Monitoring and Audit Studies. Paper presented at the First Kuwait Workshop on Environmental Impact Assessment, Kuwait, December 4-9, 1982.

Black, Peter E. 1975. Environmental impact statement in planning water and related land resources. *Water Resources Bulletin* 11(5):881-887.

Bodaly, R.A., R.E. Hecky, and R.J.P. Fudge. 1984. Increases in fish mercury levels in lakes flooded by the Churchill River Diversion, northern Manitoba. *Canadian Journal of Fisheries and Aquatic Sciences* 41:682-691.

Bodaly, R.A., T.W.D. Johnson, R.J.P. Fudge, and J.W. Clayton. 1984. Collapse of the lake whitefish (*Coregonus clupeaformis*) fishery in Southern Indian Lake, Manitoba, following lake impoundment and river diversion. *Canadian Journal of Fisheries and Aquatic Sciences* 41:692-700.

Bodaly, R.A. *et al.* 1984. Ecological effects of hydro-electric development in northern Manitoba, Canada: the Churchill-Nelson River Diversion. In *Effects of Pollutants at the Ecosystem Level (SCOPE).* (P.J. Sheehan, D.R. Miller, G.C. Butler and Ph. Boudreau, eds.) Chichester: John Wiley & Sons.

Bogner, N.F. 1978. Dam safety: techniques of building and maintaining safe dams. In *International Perspectives on Watershed Conservation.* Proceedings of the 25th National Watershed Congress, June 25-28, Toronto.

Bokhari, S.M.H. 1975a. Summary of discussion and findings on ex-post evaluation. In *River Basin Development.* Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Bokhari, S.M.H. 1975b. Ex-post evaluation of river basin development in Pakistan. In *River Basin Development.* Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Boothroyd, Peter, and William Rees. 1984. *Impact Assessment from Pseudo-Science to Planning Process: An Educational Response.* Discussion Paper No. 3, School of Community and Regional Planning, University of British Columbia, Vancouver.

Boucher, Réjean, et Dominique Roy. 1982. *Les conséquences de la coupure de la Grande Rivière sur les poissons en aval du réservoir de LG2.* Montréal: Société d'énergie de la Baie James.

Boulet, Elisabeth. 1981. *Analyse comparative de projets de développement majeurs.* Québec: Bureau de la Baie James et du Nord Québécois, Environnement Canada.

Bowden, Gary. 1983. Organizational Differences Among Energy Forecasts: The Case of U.S. Crude Oil Estimates, 1957-1974. Paper presented to the Society for the Social Study of Science.

Bridger, C., J.C. Day, and S.E. Peet. 1978. Northwestern Ontario River Diversions. Paper presented to the Annual Conference of the American Water Resources Association, Orlando, Florida.

Bright, Elise M. 1982. Secondary impacts of airports: an assessment of planning procedures. *Transportation Quarterly* 36(1)(Jan):75.

Bryant, Thomas A. 1977. Ultimate Resources of Petroleum — Social and Political Implications for Canada and the U.S.A. S.M. Thesis submitted to the Massachusetts Institute of Technology, Cambridge, Mass.

Bryant, Thomas A. 1982. Big Dam Politics: A Hindsight Evaluation of Large Multipurpose Water Projects. Ph.D. dissertation submitted to the Massachusetts Institute of Technology, Cambridge, Mass.

Buma, Paul G., and J. Chadwick Day. 1977. Channel morphology below reservoir storage projects. *Environmental Conservation* 4(4):279-284.

Caldwell, Lynton K. 1982. *Science and the NEPA: Redirecting Policy Through Procedural Reform.* University of Alabama: University of Alabama Press.

Campbell, Donald T. 1969. Reforms as experiments. *American Psychologist* 24 (April).

Carruthers, Ian D., E.S. Clayton, and F. Hamawi. 1974. *Wadi Dhuleil Jordan: An ex-post evaluation.* New York: Praeger.

Case, Fred E., and Jeffrey Gale. 1982. *Environmental Impact Review and Housing: Process Lessons from the California Experience.* New York: Praeger.

Clark, B.D. 1983. Post-development audits to test the effectiveness of environmental impact prediction methods and techniques. In *Environmental Planning for Large Scale Development Projects.* Environment Canada and Can. Petroleum Assn.

Clawson, Marion. 1979. Forests in the long sweep of American history. *Science* 204:1168-1174.

Colson, Elizabeth. 1971. *The Social Consequences of Resettlement.* Manchester, U.K.: Manchester University Press.

Conant, Francis, Peter Rogers, Marion Baumgartner, Cyrus McKell, Raymond Dasmann and Priscilla Reining (eds.) 1984. *Resource Inventory and Baseline Study Methods for Developing Countries.* Committee on Arid Lands, American Association for the Advancement of Science, Washington, D.C.

Cook, Thomas D., and Donald T. Campbell. 1976. The design and conduct of quasi-experiments and true experiments in field settings. In *Handbook of Industrial and Organizational Psychology.* (Marvin D. Dunnette, ed.) Chicago: Rand McNally College Publishers.

Couch, W.J. (ed.) 1982. *Environmental Assessment in Canada: 1982 Guide to Current Practice.* Ottawa: Canadian Council of Resource & Environment Ministers.

Council on Environmental Quality, U.S. 1976. *Environmental Impact Statements: An analysis of six years' experience by seventy federal agencies*. Special Report. Washington, D.C.

Day, J.C. 1975. International management of the River Plate Basin. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Planning, Budapest.

Dolan, Thomas, and Robert M. Maestro. 1975. The Environmental Assessment Statement as a Natural Resource Planning Tool. Paper presented at the 40th North American Wildlife and Natural Resources Conference, Pittsburgh, March 16-19.

Dorcey, Anthony H.J., and Andrew R. Thompson. 1983. Environmental Management as a Bargaining Process: For better or worse? Paper prepared for the Environmental Ethics Research Workshop, Montreal.

Dorcey, A.H.J., and B.R. Martin. 1985a. Techniques for joint management of natural resources: Getting to yes. Paper given to the Banff Conference on Natural Resources Law, Banff, Alberta.

Dorcey, A.H.J., and B.R. Martin. 1985b. *Impact assessment monitoring and management: A case study of Utah and Amax mines*. Westwater Research Centre, University of British Columbia, Vancouver.

Dorcey, A.H.J., and B.R. Martin. 1985c. *Reaching agreement in impact management: A case study of Utah and Amax Mines*. Westwater Research Centre, University of British Columbia, Vancouver.

Dougal, Merwin D. (ed.) 1969. *Flood Plan Management: Iowa's Experience*. Ames: Iowa State University Press.

Downs, Anthony. 1972. Up and down with ecology: The issue attention cycle. *The Public Interest* 28:38-50.

Duckstein, Lucien. 1975a. Decision making and planning for river basin development. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basin and Interbasin Planning, Budapest.

Duckstein, Lucien. 1975b. Summary of discussions and findings on decision-making and planning. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Planning, Budapest.

Duffy, Pat. 1980. *The Federal Environmental Assessment and Review Process: Past, present and future*. Proceedings of the 21st Annual Meeting of the Canadian Society of Environmental biologists, Ottawa, Jan. 3-4.

Eagles, Paul F.J. 1984. *The Planning and Management of Environmentally Sensitive Areas*. London: Longman.

ECE (Economic Commission for Europe). 1982. *Post Project Analysis of Environmental Impact Assessment*. (ENV/GE.1/R/2).

Efford, I.E. 1975. Assessment of the impact of hydro-dams. *Journal of the Fisheries Research Board of Canada* 32:196-209.

Environment Canada. 1975. *James Bay Hydro-electric Project: A Statement of Environmental Concerns and Recommendations for Protection and Enhancement Measures*. Environmental Monitoring Service, Environment Canada, Hull, Québec.

Environment Canada. 1983. *Environment Monitoring of Federal and Provincial Projects*. Economic and Technical Review Report EPS 3-ES-82-2. Proceedings of a Meeting held in Ottawa, January 26, 1982. Environmental Strategies Directorate, Hull, Québec.

Environment Canada and Canadian Petroleum Association. 1983. *Environmental Planning for Large-scale Development Projects*. Final Report of the International Workshop on Environmental Planning for Large-scale Development Projects, Whistler, B.C., Canada. October 2-5, 1983.

Everitt, R.R., and N.C. Sonntag. 1985. *Follow-up Study On Environmental Assessments for Selected Frontier Oil and Gas Projects*. Environmental and Social Systems Analysts Ltd. (ESSA), Vancouver, B.C.

Fairfax, Sally K. 1978. A disaster in the environmental movement. *Science* 199:743-748.

Farvar, M. Taghi, and J.P. Milton (eds.) 1972. *The Careless Technology: Ecology and International Development*. Garden City, N.Y.: The Natural History Press.

Faubert, N. 1982. Travaux d'aménagement piscicole au réservoir de LG 2. .*Canadian Water Resources Journal* 7(2):172-180.

Forces. 1982. *Numéro spécial: "Churchill Falls"*. Québec: Société d'édition de la revue forces.

Forrester, Jay W., Nathaniel J. Mass, and Charles J. Ryan. 1976. The systems dynamics national model: Understanding socio-economic behavior and policy alternatives. *Technological Forecasting and Social Change* 9:51-68.

Fowler, Robert J. 1982. *Enviromental Impact Assessment, Planning and Pollution Measures in Australia: An Analysis of Australian Environmental Impact Assessment Procedures and their Relationship with Land-use Planning and Pollution Controls*. Australian Government Publishing Service, Canberra, for the Dept. of Home Affairs and Environment.

Freeman, P.H. 1974. *The Environmental Impact of a Large Tropical Reservoir (Lake Volta, Ghana)*. Smithsonian Institute, Washington, D.C.

Friesema, H. Paul, and Paul J. Culhane. 1976. Social impacts, politics, and the environmental impact statement process. *Natural Resources Journal* 16(2):339-357.

Fritz, E.S., P.J. Rago, and I.P. Muraka. 1980. *Strategy for Assessing Impacts of Power Plants on Fish and Shellfish Populations*. Paper No. FWS/OBS-80/34, Fish and Wildlife Service, U.S. Dept. of the Interior, Washington, D.C.

Futa, A. 1975. Volta river basin development: A case study. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Gasaway, C.R. 1970. *Changes in the Fish Population in Lake Francis Case in South Dakota in the First 16 years of Impoundment*. U.S. Bureau of Sport Fish and Wildlife, Technical Paper No. 56.

Green, G.H. 1974. Effects of hydroelectric development in western Canada on aquatic ecosystems. *Journal of the Fisheries Research Board of Canada* 31:913-927.

George, Carl J. 1972. The role of the Aswan high dam in changing the fisheries of the Southeastern Mediterranean. In *The Careless Technology* (M.T. Farvar and J.P. Milton, eds.) Garden City, N.Y.: The Natural History Press.

Giannotti, David A. 1983. The environmental assessment program. *National Law Journal*, Nov. 21:14.

Goldsmith, Frank, and Ralph L. Harding. 1975. Grim lessons of the vinyl chloride cover up and PBC: Hindsight in perspective. *New Engineer* 4(10:Nov):27.

Goodland, Robert J.A. 1979. Environmental optimization in hydrodevelopment of tropical forest regions. In *Man-Made Lakes and Human Health* (R.S. Panday, ed.) Proceedings of the Symposium on Man-Made Lakes and Human Health, Faculty of Medicine, University of Suriname, Paramaribo. October 23-25, 1977.

Goodland, Robert J.A. *(in press)* Environmental Effects of Large Dams. To appear as a book review in *Nature*.

Goudie, A. 1981. *The Human Impact: Man's Role in Environmental Change*. Oxford: Blackwell.

Gray, John T. 1985a. The role of ecology in environmental planning. *Ecology* 66(1):319-320.

Gray, John T. 1985b. Review of *Planning and Ecology*, by R.D. Roberts and T.M. Roberts. *Ecology* 66(1):319-320.

Grimard, Y., and H.G. Jones. 1982. Trophic upsurge in new reservoirs: a model for total phosphorus concentrations. *Canadian Journal of Fisheries and Aquatic Sciences* 39:1473-1483.

Groupe de Travail Fédéral-Provincial. 1971. *Étude préliminaire des impacts écologiques du projet de développement de la Baie James, Province de Québec*. Rapport du Groupe de Travail Fédéral-Provincial, Ottawa.

Hafez, M., and W.K. Shenouda. 1978. The environmental impacts of the Aswan High Dam. In *Water Management for Arid lands in Developing Countries* (Askit K. Biswa, M. Abdel Hady Samaha, Mohammed H. Amer and Mahmoud Abu-Zeid, eds.) Oxford: Pergamon Press.

Hall, A., B.R. Davies, and I. Valente. 1976. Cabora Bassa: some preliminary physiochemical and zooplankton preimpoundment resutls. *Hydrobiologica* 50:17-25.

Hall, T.F., and G.F. Smith. 1955. Effects of flooding on woody plants. *Journal of Forestry* 53:281-285.

Haveman, Robert H. 1972. *The Economic Performance of Public Investments: An Ex Post Evaluation of Water Resources Investments*. Baltimore: Johns Hopkins University Press.

Hecky, R.E. 1984. Thermal and optical characteristics of Southern Indian Lake before, during, and after impoundment and Churchill River Diversion. *Canadian Journal of Fisheries and Aquatic Sciences* 41:579-590.

Hecky, R.E., R.W. Newbury, R.A. Bodaly, K. Patalas, and D.M. Rosenberg. 1984. Environmental impact prediction and assessment: the Southern Indian Lake experience. *Canadian Journal of Fisheries and Aquatic Sciences* 41:720-732.

Hirst, S.M. 1984. Applied ecology and the real world. I. Institutional Factors and Impact Assessment. *Journal of Environmental Management* 18:189:202.

Hollick, M. 1981. Environmental impact assessment as a planning tool. *Journal of Environmental Management* 12(1):79.

Holling, C.S. (ed.) 1978. *Adaptive Environmental Assessment and Management*. Chichester: John Wiley.

ICOLD (International Commission On Large Dams). 1978. *Environmental Effects of Large Dams*. A report by the United States Committee on Environmental Effects, published by the American Society of Civil Engineers, New York.

Jackson, P.B.N., and B.R. Davies. 1976. Cabora Bassa in its first year: Some ecological comparisons. *Rhodesian Science News* 10:128-133.

Jacobs, Brian D. Personal communication to Dr. T.A. Bryant, from the Senior Lecturer in Public Administration, North Staffordshire Polytechnic, Stoke-on-Trent, U.K., 8 March 1985.

Jain, Ravinder K., and Bruce L. Hutchings (eds.) 1978. *Environmental Impact Analysis: Emerging Issues in Planning*. Urbana: University of Illinois Press.

Jakeman, A.J. Personal communication to Dr. T.A. Bryant, from the Acting Head of the Centre for Resource and Environmental Studies, Australian National University, Canberra, 25 February 1985.

Jakimchuk, R.D., C.D. Schick, L.G. Sopuck, and J.M. Olynyk. 1985. *An Analysis of Vegetation, Aquatic Resource and Wildlife Issues for Three Northern Pipeline Projects Reviewed by EARP*. Renewable Resources Consulting Services Ltd., Sidney, B.C.

Janes, S.H., and W.A. Ross. 1985. *Follow-up Study to the Banff Highway Twinning Project, Alberta*. Janes and Associates Ltd., London, Ontario and University of Calgary, Alberta.

Jennings, V.E. 1976. A developer's view of environmental impact assessments. *Search* 7(6):250-253.

Johnston, Richard A. 1976. Federal environmental litigation in 1976: Kleppe vs. Sierra Club — an environmental planning Catch 22? *Harvard Environmental Law Review I*: 182-223.

Jones, M., and L. Greig. 1985. Adoptive environmental assessment management: A new approach to environmental impact assessment. In *New Directions in Environmental Impact Assessment in Canada* (Virginia W. Maclaren, and Joseph B. Whitney, eds.) Toronto: Methuen.

Karpinski, Adam, Marie-Josée Lussier, Pierre Senecal, and Normand Cazelais. 1983. *Programme "Connaissance des impacts générés par la construction d'une petite centrale en milieu urbain"* Montréal: Hydro-Québec.

Karpinski, Adam. 1984. *Suivi en phase construction — Rapport synthèse sur les impacts fonctionnels et sur l'efficacité des mesures d'insertion (sur la base d'un texte de Pierre Senecal)* Montréal: Hydro-Québec.

Kiell, D.J., J.L. Barnes, and E.L. Hill. 1985. *Follow-up to Environmental Impact Assessment: Hinds Lake, Upper Salmon and Cat Arm Hydro-electric Development in Newfoundland*. Newfoundland and Labrador Hydro Group.

Knetsch, Jack L., and Peter H. Freeman. 1979. Environmental and economic assessments in development project planning. *Journal of Environmental Management* 9(3):237-247.

Kroodsma, Roger L. 1985a. Assessing the loss of wildlife habitat in environmental impact statements. *Wildlife Society Bulletin* 13:82-87.

Kroodsma, Roger L. 1985b. Personal communication to Dr. T.A. Bryant, from the Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Kuhn, Thomas S. 1970. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Lagler, C. (ed.) 1969. *Man-Made Lakes*. Rome: UN Food and Agriculture Organization.

Larkin, P.A. 1984. A commentary on environmental impact assessment for large projects affecting lakes and streams. *Canadian Journal of Fisheries and Aquatic Sciences* 41:1121-1127.

Lash, T.J.F., D.E.L. Maasland, G. Filteau, and P. Larkin. 1974. On doing things differently: an essay on environmental impact assessment of major projects. *Issues in Canadian Science Policy* 1:9-16, Science Council of Canada, Ottawa.

Leed, Roger M. 1975. The NEPA of 1969: Is the fact of compliance a procedural or substantive question? *Santa Clara Lawyer* 15 (Winter).

Lehmkhuhl, D.M., H.V. Danks, V.M. Behan-Pelletier, D.J. Larson, D.M. Rosenberg, and I.M. Smith. 1984. *Recommendations for the Appraisal of Environmental Disturbance: Some General Guidelines, and the Value and Feasibility of Insect Studies*. Supplement to the Bulletin of the Entomological Society of Canada 16.

Leshy, John D. 1976. Energy and the Public Lands: NEPA Compliance. Paper presented at the Environmental Law Institute's Conference on Energy and the Public Lands, Utah. Aug. 23-26.

Lewis-Back, Michael S. 1985. Election forecasts in 1984: How accurate were they? *PS Winter*:53-62.

Lieber, Harvey. 1981. Review of *The Reserve Mining Controversy*, by R.V. Bartlett. *Journal of the Water Pollution Control Federation*, April:192a-193a.

Lindstrom, T. 1973. Life in a lake reservoir: Fewer options, decreased production. *Ambio* 2:145-153.

Liroff, Richard. 1975. *NEPA and Its Aftermath: the Formation of a National Policy for the Environment*. Bloomington: Indiana University Press.

Liroff, Richard. 1980. Judicial Review under NEPA: Lessons for Users of Various Approaches to Environmental Impact Assessment. Report E-80-2 of the Environmental Law Institute, for the Chief of Engineers, U.S. Army.

Little, Arthur D. 1984. *Current Practices in Environmental Auditing*. For the U.S. Environmental Protection Agency, Washington, D.C.

Loar, J.M., S.G. Hildebrand, and T. Negat Veziroglu. 1980. A comparison of environmental issues related to development of small hydropower resources at new versus existing sites. In *Proceedings of 3rd Miami International Conference on Alternative Energy Sources, Miami Beach, Florida* (T.N. Veziroglu, ed.) University of Miami: Clean Energy Research Institute.

Lord, William B. 1981. Objectives and constraints in federal water resources planning. *Water Resources Bulletin* 17(7):1060-1065.

Lowe-McConnell, R.H. (ed.) 1966. *Man-Made Lakes*. New York: Academic Press.

Lusis, M. 1981. Air quality research and management in the Long Point, Haldimand-Norfold area. *Journal of Urban Environmental Affairs* 12(3):65-79.

Lwehabura, D.K. 1975. Planning and development of the Kagera river basin: Experience and current issues. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

MacDonald, Alex, presenter. 1985. *Forecasts: The uncertain prophets*. Transcripts of radio shows aired by CBC on "Ideas", April 24 and May 1.

MacLaren, Virginia, and Joseph B. Whitney (eds.) 1985. *New Directions in Environmental Impact Assessment in Canada*. Toronto: Methuen.

Macinko, George. 1963. The Columbia Basin projects: Expectations, realizations, implications. *The Geographical Review* (April) 53(2):186-199.

Macinko, George 1975. The Columbia basin project reappraised. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Mageed, Y.A. 1975. Problems encountered in integrated river basin development: Case study of the River Nile. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Marcus, Linda Graves. 1979. *A Methodology for Post-EIS Monitoring*. U.S. Geological Survey, Circular 782.

Marsh, G.P. 1864. *Man and Nature or Physical Geography as Modified by Human Action*. New York: Scribner.

Martin, Brian Randall. 1985. The Causes of Scientific Disputes in Impact Assessment and Management: The Utah Mines Case. Master's Thesis, School of Community and Regional Planning, University of British Columbia, Vancouver.

Matthews, William H. 1975. Objective and subjective judgments in environmental impact analysis. *Environmental Conservation* 2(2):121-132.

Mazur, Allan. 1973. Disputes between experts. *Minerva*:243-262.

McCallum, David R. 1984. Environmental Follow-up to Federal Projects (Draft Report). Environmental Impact Systems Division, Environment Canada, Hull, Quebec.

McCart, P.J. 1982. Aquatic monitoring of representative developments. In *Symposium On Environmental Monitoring* (S.B. Smith, ed.) Alberta Society of Professional Biologists, Edmonton.

McCormick, Jack, & Associates. 1977. *Effects of the NEPA on Corporate Decision Making*. Office of Environmental Affairs, U.S. Dept. of Commerce, Washington, D.C.

Moncrieff, I., L. Torrens, E. Mackintosh, *et al.* 1985. *An Environmental Performance Audit for Selected Pipeline Projects in Southern Ontario*. Union Gas Ltd., Maclaren Plansearch Inc., Ecological Services for Planning Ltd.

Munn, R.E. 1975. Environmental Impact Assessment. Paper presented to the International Congress of Scientists on the Human Environment, Kyoto, Japan. Nov. 16-26.

Munn, R.E. 1979. *Environmental Impact Assessment: Principles and Procedures* (SCOPE 5), 2nd ed. Toronto: John Wiley & Sons.

Munro, David A. 1986. Environmental impact assessment as an element of environmental management. In *Cumulative Environmental Effects: A Binational Perspective* (CEARC and NRC, eds.) Federal Environmental Assessment Review Office, Hull, Québec.

Munro, David A., and A. Matte-Baker. 1984. Policy Formulation and Planning in Relation to Sustainable Development. Paper prepared for IUCN/UNU seminar, Achieving Sustainable Development, Montreal, Canada.

Nelkin, Dorothy. 1974. The role of experts in a nuclear siting controversy. *Bulletin of the Atomic Scientists*:29-36.

Nelkin, Dorothy. 1979. *Controversies*. Beverly Hills: Sage Publications.

Newbury, R.W., G.K. McCullough, and R.E. Hecky. 1984. The Southern Indian Lake Impoundment and Churchill River diversion. *Canadian Journal of Fisheries and Aquatic Sciences* 41:548-557.

Nielson, L.J. 1967. Evaluation of pre-impoundment conditions for prediction of stored water quality. In *Reservoir Fishery Resources Symposium*. American Fisheries Society, Washington, D.C.

Nilsson, N.A. 1973. Biological effects of water-power exploitation in Sweden, and means of compensation for damage. In *Commission Internationale des Grands Barrages* (ICOLD), Madrid.

Nursall, J.R. 1952. The early development of a bottom fauna in a new power reservoir in the Rocky Mountains of Alberta. *Canadian Journal of Zoology* 30:387-409.

Nursall, J.R. 1969. Faunal changes in oligotrophic man-made lakes: Experience on the Kananaskis River system. In *Man-Made Lakes* (L.E. Obeng, ed.) Accra: University of Ghana Press.

Obeng, L.E. (ed.) 1969. *Man-Made Lakes*. Accra: University of Ghana Press.

Obeng, L.E. 1978. Starvation or bilharzia? — a rural development dilemma. In *Water and Society: Conflicts in Development* (C.G. Widstrand, ed.) Oxford: Pergamon Press.

Ogden, J.G. 1981. The politics of water quality. In *Water and Environmental Law*. Proceedings of a conference at Dalhousie University, Halifax. Sept. 14-16. Institute for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia.

Oglesby, Ray T., Clarence A. Carlson, and James A. McCann (eds.) 1972. *River Ecology and Man*. New York: Academic Press.

Omo-Fadaka, Jimoh. 1978. Where super-dams have failed: The negative aspects of mammoth water projects. PHP (Tokyo), reprinted in *Atlas World Press Review*, December:45.

Ontario Ministry of Natural Resources and Canadian Wildlife Service, Ontario Region. 1984. *An Evaluation System For Wetlands of Ontario South of the Precambrian Shield*. Second ed., March.

Organization for Economic Co-operation and Development. 1979. *Environmental Impact Assessment: Analysis of the Environmental Consequences of Significant Public and Private Projects*. Paris: OECD.

O'Riordan, J. 1971. *Perspectives on Resource Management*. London: Pion.

O'Riordan, J. 1972. An approach to evaluation in multiple objective river basin planning, an analysis of selected water quantity alternatives in the Okanagan Valley, British Columbia. In *Proceedings of the International Symposium on the Planning of Water Resources (vol. 3)*, Mexico City, 1972.

O'Riordan, J. 1985. Environmental Planning Project Assessment and Regulations: Forging the links in the chain. Paper presented at the Workshop on Environmental Impact Procedures in Australia, Canada and New Zealand. New Zealand, March 28, 1985.

O'Riordan, Timothy, and W.R. Derrick Sewell. 1981. *Project Appraisal and Policy Review*. New York: John Wiley & Sons.

Orloff, Neil. 1972. Suggestions for Improvement of the Environmental Impact Statement Program. Paper presented at the Environmental Impact Analysis Symposium, Green Bay, Wisconson.

Panday, R.S. (ed.) 1979. *Man-made lakes and Human Health*. Proceedings of the Symposium of Man-Made Lakes and Human Health, Faculty of Medicine, University of Suriname, October 23-25, 1977, Paramaribo, Suriname.

Panero, Robert B. 1969. A dam across the Amazon. *Science Journal* 5A:55-60.

Panero, Robert B. 1972. *The Amazon — a Catalytic Approach to Development*. Report HI-1664-RR of the Hudson Institute, Hudson, N.Y.

Parsons, The Ralph M., Co. 1964. North American Water and power alliance. *News & Views* (7).

Penn, A.F. 1975. Development of James Bay: The role of environmental impact assessment in determining the legal right to an interlocutory injunction. *Journal of the Fisheries Research Board of Canada* 32(1):136-160.

Phasartseree, Mongkol. 1982. A conceptual development of quantitative environmental impact assessment methodology for decision makers. *Journal of Environmental Management* 14:4 (June):301.

Planning and Evaluation Directorate. 1982. Program Evaluation: Federal Environmental Assessment and Review Process (EARP), as of June 30, 1982. Corporate Planning Group, Environment Canada, Hull, Québec.

Plewes, M., and J.B.R. Whitney (eds.) 1977. *Environmental Impact Assessment In Canada: Processes And Approaches*. Publication No. EE-5, Institute for Environmental Studies, University of Toronto, Toronto.

Potter, L., D. Kidd, and D. Standiford. 1975. Mercury levels in Lake Powell: Bioamplification of mercury in a man-made desert reservoir. *Environmental Science and Technology* 9(1):41-46.

Québec, Éditeur officiel du Québec. 1975. *The James Bay Northern Quebec Agreement*.

Rees, W.E. 1983. Environmental assessment of hydrocarbon production from the Canadian Beaufort Sea. *Env. Impact Assessment Rev.* 4:539-555.

Ress, S. 1975. Ex-post evaluation of socio-economic effectiveness of large water resources projects. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Rigby, B. 1985. Post development audits in environmental impact assessment. In *New Directions in Environmental Impact Assessment in Canada*. (Virginia W. MacLaren and Joseph B. Whitney, eds.) Toronto: Methuen.

Roberts, R.D., and T.M. Roberts. 1984. *Planning and Ecology*. New York: Chapman and Hall.

Robertson, Ian. Personal communication to Dr. T.A. Bryant, from the Dept. of Arts, Heritage and Environment, Canberra, Australia, 3 April 1985.

Roche Envirobec Associés Ltée. 1985. *Surveillance du niveau acoustique pour l'année 84: Aménagement Rivière-des-Prairies*. Montréal: Hydro-Québec.

Rogers, Peter P. 1978. Memo to the Kosi Project Team, Harvard Cambridge, Mass.

Rogers, Peter P. 1985. Personal communication to Dr. T.A. Bryant, from Harvard University, Cambridge, Mass.

Rosenberg, D.M., V.H. Resh, S.S. Balling, M.A. Barnby, J.N. Collins, D.V. Durbin, T.S. Flynn, D.D. Hart, G.A. Lamberti, E.P. McElravy, J.R. Wood, T.E. Blank, D.M. Schultz, D.L. Marrin, and D.G. Price. 1981. Recent trends in environmental assessment. *Canadian Journal of Fisheries and Aquatic Sciences* 38(5):591-624.

Rosenberg, D.M., R.A. Bodaly, R.E. Hecky, and R.W. Newbury. *(in press) The Environmental Assessment of Impoundments and Diversions in Canada*. Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba.

Rowsell, J.A., and P. Seidl. 1985. *The Effectiveness of the Environmental Assessment and Review Process as Applied to Watercourse Crossings on the Sarnia-Montreal Pipeline*. Amik Resources Group, Toronto, Ontario.

Roy, D. 1980. Environmental protection at the La Grande complex: realizations in the framework of the LG2 project. In *Proceedings of the Canadian Society of Environmental Biologists*, 21st Annual Meeting, Ottawa, Jan. 3-4.

Roy, Dominique *et al.* 1982. *Rapport d'étape du réseau de surveillance écologique*. Montréal: SEBJ Environnement.

Rubin, N. 1975. African dams: Some reflections with hindsight. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest.

Rubin, N., and W.N. Warren (eds.) 1968. *Dams In Africa: An Interdisciplinary Study of Man-Made Lakes In Africa*. London: Cass.

Ruggles, C.P. 1985. *Follow-up Ecological Studies at the Wreck Cove Hydro-electric Development, Nova Scotia*. Monenco Consultants Ltd., Halifax, Nova Scotia.

Rzoska, J. 1965. The biology of reservoirs in the U.S.S.R. In *Man-Made Lakes* (R.H. Lowe-McConnell, ed.) New York: Academic Press.

Sadler, Barry. 1984. Energy Development in the Arctic Frontier of Canada: An analysis of project decision making. Paper presented at the International Seminar on Strategies for Environmentally Sound Development in the Mining and Energy Industries, Greece. October 21-24, 1984.

Saether, O.A. 1980. The influence of eutrophication on deep lake benthic invertebrate communities. *Progress in Water Technology* 12:161-180.

Sandbach, F. 1978. A further look at the environment as a political issue. *International Journal of Environmental Studies* 12:99-110.

Schaffer, R.C. 1974. Sociological analysis of dam impact: A study of twenty-two large dams in Texas. In *Reservoir Impact Study*, Texas A&M University, College Station, Texas.

Schermerhorn, R.W. 1974. *Boise Post-audit Study, Plan of Study Subproject Report*. Completion report, Idaho Water Resources Research Institute, Moscow, Idaho.

Scudder, Thayer. 1972. Ecological bottlenecks and the development of the Kariba basin. In *The Careless Technology: Ecology and International Development* (M.T. Farvar and J.P. Milton, eds.) Garden City, N.Y.: The Natural History Press.

Scudder, Thayer 1975. Social impacts of the integrated river basin development on local populations. In *River Basin Development*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Planning, Budapest.

Senecal, Pierre. 1983. *Examen de la problématique des impacts sociaux dans le cadre du projet "Rivière-des Prairies (évacuateur de crues)"* Montréal: Hydro-Québec.

Sewell, W.R.D. 1964. The Columbia River Treaty and protocol agreement. *Nat. Res. Journal* (4):309-331.

Sewell, W.R.D. 1966. The Columbia River Treaty: some lessons and implications. *Can. Geographer* (10):145-156.

Shamsedin, E.M. 1968. The Economic Impact of Development: A Case Study of the Litani River and other Projects in Lebanon. Ph.D. Dissertation, University of Florida.

Sheaffer, John R. 1969. The interaction of urban development and flood plain management in Waterloo, Iowa. In *Flood Plain Management: Iowa's Experience* (M. Dougal, ed.) Ames: Iowa State University Press.

Smith, S.B. 1978. Philosophy, technology and politics of environmental impact assessment. *Chemistry in Canada*, February: 13-18.

Société d'énergie de la Baie James (SEBJ). 1985. *Direction ingenierie et environnement — exploitation. Manuel d'exploitation Complex La Grand - Phase 1. Volume 1: Consignes relatives à la protection de l'environnement; Volume 2: Recueil des planches*. Montréal: SEBJ.

Soucy, A. 1978. L'environnement du Territoire de la Baie James et les principles répercussions du projet. *L'ingénieur* 325:13-24.

Spencer, R.B. 1985. *Shakwak Follow-up Investigation*. Spencer Environmental Management Services Ltd., Edmonton.

Susskind, Lawrence. 1985. Personal letter to Dr. T.A. Bryant, dated April 30, Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Mass.

System Engineering Division, B.C. Hydro and Power Authority. 1974. *Report on the Seven Mile Project Mitigation of Environmental Impact and Selection of Access Road*. Vancouver.

Therrien, D. 1982. Les aménagements correctifs d'environnement au complexe la Grande. *Canadian Water Resources Journal* 7(2):147-162.

Thomas, W.L. 1956. *Man's Role in Changing the Face of the Earth*. Chicago: University of Chicago Press.

Thompson, A.R. 1983. Science and beyond in environmental impact assessment. In *Environmental Planning for Large-Scale Development Projects* (Environment Canada and Can. Petroleum Association) Final Report of the International Workships on Environmental Planning for Large-Scale Development Projects, Whistler, B.C.

Thormann, Peter H. 1972. Labour-intensive irrigation works and dam construction: A review of some research. *International Labour Review* 106(2-3):151-166.

Thurlow, W.J. 1976. The meaning of an environmental impact statement to project development. In *Proceedings: Environment II*. Association of Consulting Engineers of Canada, Montreal, Sept. 28-29.

UK (United Kingdom) Foreign and Commonwealth Office. 1983. *Planning and the Environment in Britain*. Reference Services, Central office of Information, London.

UK (United Kingdom) Department of the Environment. 1984. The U.K. and Environmental Assessment. Mimeo.

Unesco. 1969. *Status and Trends of Research in Hydrology, 1965-74*. Proceedings of an International Conference, Dec. 8-16, Unesco headquarters, Paris.

United Nations. 1958. *Integrated River Basin Development: Report by a Panel of Experts*. United Nations, New York.

UNDP (United Nations Development Program). 1975. *River Basin Development: Policies and Planning*. Proceedings of the UNDP Regional Seminar on River Basins and Interbasin Development, Budapest, Sept. 16-26.

U.S. Commission of Federal Paperwork. 1977. A Report on Environmental Impact Statements. Staff report.

U.S. Federal Council for Science and Technology. 1968. *Water Resources Policy and Political Institutions*. Panel Report, Office of Science and Technology, Washington, D.C.

Verdon, Richard. 1985. Impact of Spillway Construction on Water Quality, on Fish Distribution and Abundance in the Des Prairies River and on Background Noise in the Local Community. Paper presented at The Workshop on Environmental Assessment Verification, Experience and Utilisation; Canadian Electrical Utilities/Ontario Hydro Conference and Development Centre, Orangeville, Ont. September 17-19, 1985.

Wagner, M.W. 1984. Post impoundment change in financial performance of the Southern Indian Lake commercial fishery. *Canadian Journal of Fisheries and Aquatic Sciences* 41:715-719.

Warwick, W.F. 1978. Man and the Bay of Quinte, Lake Ontario: 2800 years of cultural influence, with special reference to the Chironomidae (Diptera), sedimentation and eutrophication. Ph.D. dissertation, University of Manitoba, Winnipeg.

Warwick, W.F. 1980. Paleolimnology of the Bay of Quinte, Lake Ontario: 2800 years of cultural influence. *Canadian Bulletin of Fisheries and Aquatic Sciences* 206:1-117.

Wenner, Lambert N. (ed.) 1984. *Issues in Social Impact Analysis*. Proceedings of an Interagency Symposium, U.S. Forest Service, Dept. of Agriculture, Washington, D.C.

Weiner, Mervyn. 1984. Paper presented to the Annual Meeting of the Canadian Evaluation Society, University of Ottawa.

Widstrand, Carl G. (ed.) 1978. *Water And Society: Conflicts in Development, Part 1: The Social and Ecological Effects of Water Development in Developing Countries*. Oxford: Pergamon Press. (First published as *Water Supply and Management* (1978), Vol 2, No.4).

Wiens, A.P., and D.M. Rosenberg. 1984. Effect of impoundment and river diversion on profundal macrobenthos of Southern Indian Lake, Manitoba. *Canadian Journal of Fisheries and Aquatic Sciences* 41:638-648.

Wilkinson, J.C. 1977. *Water And Tribal Settlement In South-East Arabia: A Study Of The Aflaj Of Oman*. Oxford: Clarendon Press.

Willis, Byron H. 1975. Research needs relative to environmental data. *Journal of the Hydraulics Division — ASCE* 101(11):1423-1432.

World Bank. 1974. *Environment Health and Human Ecologic Considerations in Economic Development Projects*. Washington, D.C.

Worthington, E. Barton. 1978. The greening of the desert: What cost to farmers? *Civil Engineering* 48(8):60-63.

Yockell, Claude. 1984. *Aménagement Rivière-des-Prairies: Remplacement de l'évacuateur de crue surveillance du niveau sonore pour la période de juillet à décembre 1983*. Roche Environbec pour Hydro-Québec.

Young, K.R. 1980. Integration of environmental and engineering planning. In *Proceedings of the Canadian Society of Environmental Biologists*, 21st Annual Meeting, Ottawa, Jan. 3-4.

Zallen, M., J. McDonald, and P. Richwa. 1985. *Follow-up Review of Projected and Residual Impacts Within the Coquihalla Valley, B.C.* Environmental Sciences Limited (ESL), Vancouver.

APPENDIX I

FOLLOW-UP STUDIES OF ENVIRONMENTAL IMPACT ASSESSMENTS PREPARED FOR THE ENVIRONMENTAL PROTECTION SERVICES (EPS) OF ENVIRONMENT CANADA

Dorcey, A.H.J., Martin B.R., Westwater Research Centre, University of British Columbia, Vancouver, British Columbia (1985) "Impact Assessment, Monitoring and Management: A Case Study of Utah and Amax Mines."

—— (1985) "Reaching Agreement in Impact Management: A Case Study of Utah and Amax Mines."

Everitt, R.R., Sonntag, N.C., Environmental and Social Systems Analysts Ltd. (ESSA), Vancouver, British Columbia. (1985) "Follow-up Study On Environmental Assessments for Selected Frontier Oil and Gas Projects."

Jakimchuk, R.D., Schick, C.D., Sopuck, L.G., Olynyk, J.M., Renewable Resources Consulting Services Ltd., Sidney, British Columbia. (1985) "An Analysis of Vegetation, Aquatic Resource and Wildlife Issues for Three Northern Pipeline Projects Reviewed by EARP."

Janes, S.H., Ross, W.A., Janes and Associates Ltd., London, Ontario and University of Calgary, Alberta. (1985) "Follow-up Study to the Banff Highway Twinning Project, Alberta."

Kiell, D.J., Barnes, J.L., Hill, E.L., Newfoundland and Labrador Hydro Group. (1985) "Follow-up to Environmental Impact Assessment: Hinds Lake, Upper Salmon and Cat Arm Hydro-electric Development in Newfoundland."

Moncrieff, I., Torrens, L., Mackintosh, E., et al., Union Gas Ltd., Maclaren Plansearch Inc., Ecological Services for Planning Ltd. *et al.* (1985) "An Environmental Performance Audit for Selected Pipeline Projects in Southern Ontario."

Rowsell, J.A., Seidl, P., Amik Resources Group, Toronto, Ontario. (1985) "The Effectiveness of the Environmental Assessment and Review Process as Applied to Watercourse Crossings on the Sarnia-Montreal Pipeline."

Ruggles, C.P., Monenco Consultants Ltd., Halifax, Nova Scotia. (1985) "Follow-up Ecological Studies at the Wreck Cove Hydro-electric Development, Nova Scotia."

Spencer, R.B., Spencer Environmental Management Services Ltd., Edmonton, Alberta. (1985) "Shakwak Follow-up Investigation."

Zallen, M., McDonald, J., Richwa, P. Environmental Sciences Limited (ESL), Vancouver, British Columbia. (1985) "Follow-up Review of Projected and Residual Impacts Within the Coquihalla Valley, B.C."

APPENDIX II

LIST OF INTERVIEWS

(Cited in the text as "surname (1985-i)")

Baker, Robert	EPS, Environment Canada
Clawson, Marion.	Resources for the Future
Cosburn, Paul.	Maclaren Plansearch
Day, J.C. (Chad).	Simon Fraser University
Donaldson, Graham.	World Bank (OED)
Dorcey, Anthony.	Westwater Research Centre
Everitt, Robert.	Environmental and Social Systems Analysts
Fitzgerald, Richard.	U.S. Forest Service
Foerstal, Hans.	Inland Waters Directorate, Environment Canada
Frederick, Kenneth.	Resources for the Future
Goldsmith, Bernice.	Concordia University
Goodland, Robert.	World Bank
Granger, Daniel.	Hydro-Québec
Hamilton, Andrew.	International Joint Commission (USA-Canada)
Hill, Edward.	Newfoundland and Labrador Hydro
Horberry, John.	Development Analysis and Programming Inc.
Jacobs, Peter.	Université de Montréal
Jakimchuk, Ronald.	Renewable Resources Consulting Services Ltd.
Janes, Steven.	S.H. Janes and Associates Ltd.
Karpinski, Adam.	Hydro-Québec
Kiell, David.	Newfoundland and Labrador Hydro
Lee, James.	World Bank
McCallum, David.	EPS, Environment Canada
Moenig, Ted.	Environment Canada
Pentland, Ralph.	Inland Waters Directorate, Environment Canada
Printz, Burt.	U.S. Agency for International Development
Quinn, Frank.	Inquiry on Federal Water Policy
Rivet, Claude.	Hydro-Québec
Rosenberg, David.	Freshwater Institute, Department of Fisheries and Oceans
Rowsall, James.	Amik Resource Group
Roy, Dominique.	SEBJ (Société d'énergie de la Baie James)
Ruggles, Paul.	Monenco Maritime
Runnals, David.	International Institute for Environment and Development
Schick, Craig.	Renewable Resources Consulting Services Ltd.
Spencer, Richard.	Spencer Environmental Services
Stoel, Thomas.	Natural Resources Defence Council
Thompson, Andrew.	Westwater Research Centre
Torrens, Lloyd.	Maclaren Plansearch
Verdon, Richard.	Hydro-Québec
Weir, Robert.	EPS, Environment Canada
Wenner, Burt.	US Forest Service
Wolff, Paul.	Canadian International Development Agency
Zallen, Morris.	Environmental Sciences Ltd.

APPENDIX III

PARTICIPANTS AT THE WORKSHOP ON AUDITS OF ENVIRONMENTAL IMPACT ASSESSMENTS 9-10 JULY 1985, TORONTO

Robert Baker
Environmental Protection Service
Ottawa, Ont.
K1A 0C8

Gordon Beanlands
FEARO
1318 Robie Street
Halifax, N.S.
B3H 3E2

Thomas Bryant
Brystra Consultants
2550 15th Ave.
Regina, Sask.
S4P 1A5

Sandy Constable
Canadian Resourcecon
#309, 811 Beach St.
Vancouver, B.C.
V6I 2B5

Anthony H.J. Dorcey
Westwater Research Centre
University of B.C.
Vancouver, B.C.
V6T 1W5

Steve Janes
S.H. Janes & Assoc.
363 Grosvenor St.
London, Ont.
N6A 1X2

David Kiell
Newfoundland & Labrador Hydro
St. Johns, Nfld.
A1A 2H3

Andrea Matte-Baker
Naivasha Consultants
2513 Amherst Ave.
Sidney, B.C.
V8L 2H3

Ian Moncrieff
Union Gas
50 Keil Dr. N.
Chatham, Ont.
N7M 5M1

David A. Munro
Naivasha Consultants
2513 Amherst Ave.
Sidney, B.C.
V8L 2H3

Robert Everitt
ESSA
678 W. Broadway
Vancouver, B.C.
V5Z 1G6

Charles Ferguson
Inco, 44th Floor
1st Canadian Place
Toronto, Ont.
M5X 1C4

George Greene
George Greene Consultants
66 Lees Ave.
Ottawa, Ont.
K1S 0B9

James Rowsell
Amik Resources Group
Ste. 112, 5955 Airport Rd.
Mississauga, Ont.
L4V 1R9

Morris Zallen
Environmental Sciences Ltd.
34, 1035 Richards St.
Vancouver, B.C.
V6B 3EH

W.A. Ross
Faculty of Environmental Design
University of Calgary
Calgary, Alta.
T2N 1N4

Paul Ruggles
Monenco Consultants
5670 Spring Garden Rd.
Ste. 801
Halifax, N.S.
B3J 3S1

Craig Schick
Renewable Resources Consulting Services Ltd.
9865 W. Saanich Rd.
Sidney, B.C.
V8L 3S1

Richard Spencer
Spencer Environmental Management Services
#414, 10310 — 102 Ave.
Edmonton, Alta.
T5J 2X6

CANADIAN ENVIRONMENTAL ASSESSMENT RESEARCH COUNCIL
MEMBERSHIP LIST — 1986

Audrey Armour
Assistant Dean and
Assistant Professor
Faculty of Environmental
Studies
York University
4700 Keele Street
North York, Ontario
M3J 1P3

Raymond J. P. Brouzes
Director, Environmental
Affairs
Alcan Aluminum Ltd.
1188 Sherbrooke Street West
Montreal, Quebec
H3A 3G2

Gerry T. Glazier
Executive Director
The Nature Conservancy
of Canada
Suite 1704
2200 Yonge Street
Toronto, Ontario
M4S 2C6

Andrew L. Hamilton
Environmental Advisor
International Joint
Commission
18th Floor, Berger Bldg.
100 Metcalfe Street
Ottawa, Ontario
K1P 5M1

Arthur J. Hanson
(Chairperson, CEARC)
Director, Institute for Resource
and Environmental Studies
Dalhousie University
1312 Robie Street
Halifax, Nova Scotia
B3H 3E2

André Marsan
President, André Marsan & Associates
615 Belmont Street
Montreal, Quebec
H3B 2L8

Jon O'Riordan
Director of Planning
Ministry of Environment
Government of British Columbia
3rd Floor, 777 Broughton Street
Victoria, British Columbia
V8W 1E3

Grace Patterson
Vice Chairperson
Environmental Assessment Board
1 St. Clair Avenue West
5th Floor
Toronto, Ontario
M4V 1K7

Nicholas W. Poushinsky
Secretary, Social Resources
Committee of Cabinet
338 Legislative Bldg.
450 Broadway Avenue
Winnipeg, Manitoba
R3C 0C8

E. Fred Roots
Science Advisor
Environment Canada
23rd Floor, North Tower
Les Terrasses de la Chaudière
10 Wellington Street
Hull, Quebec
K1A 0H3

Peter Jacobs
Professeur titulaire
Université de Montréal
Faculté de l'Aménagement
5620, avenue Darlington
Montreal, Quebec
H3T 1T2

CEARC SECRETARIAT

Gordon E. Beanlands
(Executive Secretary, CEARC)
Director of Research
Federal Environmental Assessment Review Office
1318 Robie Street
Halifax, Nova Scotia
B3H 3E2

M. Husain Sadar
(Manager, CEARC)
Scientific Advisor
Federal Environmental Assessment Review Office
13th Floor, Fontaine Bldg.
200 Sacré-Cœur Blvd.
Hull, Quebec
K1A 0H3

Robert G. Connelly
Acting Director General,
Policy and Administration
Federal Environmental Assessment Review Office
13th Floor, Fontaine Bldg.
200 Sacré-Cœur Blvd.
Hull, Quebec
K1A 0H3

Barry Sadler
Director, Institute of the North American West
1703 Ash Road
Victoria, British Columbia
V8N 2T7

Robert H. Weir
Chief, Impact Systems Division
Environmental Protection Service
Environment Canada
15th Floor, Place Vincent Massey
351 St. Joseph Blvd.
Hull, Quebec
K1A 1C8

Mary Margaret Healy
(Administrative Support, CEARC)
Administrative Assistant
Federal Environmental Assessment Review Office
13th Floor, Fontaine Bldg.
200 Sacré-Cœur Blvd.
Hull, Quebec
K1A 0H3